PB-215 601

PILOT PLANT STUDIES ON SECONDARY TREATMENT OF POTATO PROCESSING WASTES

Robert W. Vivian, et al

Pacific Northwest Water Laboratory
Corvallis, Oregon

January 1968

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POTATO PROCESSING WASTES:

PROGRESS REPORT on PILOT PLANT STUDIES OF SECONDARY TREATMENT

January 1968

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FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHWEST REGION
Pacific Northwest Water Laboratory
Corvallis, Oregon

PROGRESS REPORT

PILOT PLANT STUDIES ON SECONDARY TREATMENT OF POTATO PROCESSING WASTES

Prepared by

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Report No. PR-4

U. S. Department of the Interior
Federal Water Pollution Control Administration
Northwest Region
Pacific Northwest Water Laboratory
Corvallis, Oregon

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ABBREVIATIONS

BOD_5	5-day biochemical oxygen demand
COD_m	National Canner's Association modified chemical oxygen demand
COD_s	Standard Method chemical oxygen demand
SS	Suspended solids
VSS	Volatile suspended solids
TDOC	Total dissolved organic carbon
TS	Total solids
TVS	Total volatile solids
mgd	Million gallons per day

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PROGRESS REPORT
PILOT PLANT STUDIES ON SECONDARY TREATMENT
OF POTATO PROCESSING WASTES

I. INTRODUCTION

A. Problem

Potato processing in Idaho has had a rapid expansion during the past 15 years. The $23,235,457 payroll and $52,085,335 plant investment by the eleven Potato Processors of Idaho members in 1965-66 represent growth of more than 10 times that of comparable 1950 figures[1]. Waste production has, unfortunately, kept pace with their growth.

Potato wastes are one of the major pollutional sources in the State of Idaho. Even with primary treatment afforded by all processing plants, these wastes, in combination with other wastes, have resulted in fish kills and other pollution problems during periods of low flow in receiving streams. The potato processors are now faced with providing secondary treatment for their wastes and recognize that the cost of waste treatment must be considered to be part of the cost of doing business. Processors know that they must minimize the cost of waste treatment to be both competitive and profitable.

B. Authority

Federal authorization for this type of study comes from the Federal Water Pollution Control Act as amended. Sec. 5(b) of the Act provides that the Federal Water Pollution Control Administration (FWPCA)

may, "upon request of any State water pollution control agency, conduct investigations... concerning any specific problem of water pollution confronting any... industrial plant, with a view to recommending a solution of such problem."

The regional office of the FWPCA received a verbal request for technical assistance from the Idaho State Health Department in July 1966 in the development of secondary treatment methods for potato process waste water. The Technical Projects Branch of the FWPCA located in the Pacific Northwest Water Laboratory (PNWL) in Corvallis, Oregon, was selected to participate in the study since this was a logical extension of a previously authorized Technical Projects study on aerated lagoon treatment of food processing wastes. A memorandum of understanding authorizing the study was drawn up and signed by the three participating groups: Potato Processors of Idaho, Idaho State Health Department, and Technical Projects, FWPCA, PNWL, in January 1967. A copy of the memorandum is in Appendix A.

C. Objective and Scope

The objective of this study is to conclude pilot plant studies on feasible methods of secondary treatment of potato processing wastes. Two specific methods are being investigated: an anaerobic lagoon followed by a surface-aerated, aerobic lagoon and an aerobic lagoon system.

Due to late arrival of a surface-aerator this progress report covers only the first system - an anaerobic lagoon followed by a surface-aerated, aerobic lagoon.

D. Acknowledgments

The assistance of the Idaho State Health Department, J. R. Simplot Co. and the consulting firm of Cornell, Howland, Hayes, and Merryfield in instituting, formulating, and completing the present studies is gratefully acknowledged.

In addition, appreciation is due the Wayne Wiscomb Co. for supplying the surface aerator used in the aerated pond.

II. SUMMARY

This report outlines the operation of and results from a pilot plant used to treat potato wastes from January 1 to June 1, 1967.

Primary clarifier effluent was fed to the first of two small lagoons in series. The first lagoon was operated as a complete mixed anaerobic unit and the second lagoon was aerated with a small surface aerator. Hydraulic loadings were varied to give detention times of 8.8, 5.0, and 2.4 days in each lagoon.

Preliminary conclusions drawn from the information gathered during this period include:

1. The BOD_5 in potato wastes can be reduced by greater than 90 percent by primary clarification plus anaerobic-aerobic lagoons in series.

2. Mixing of the contents of the anaerobic lagoon is necessary for proper operation of the anaerobic-aerobic system.

3. Covering the anaerobic lagoon will reduce the temperature drop and help control odors.

4. Secondary clarification for removal of suspended solids will be required following the aerobic lagoon.

5. Foaming may cause operational difficulties in full-scale aerobic lagoons, but can be controlled by proper design.

6. Preliminary cost estimates show that a combination of anaerobic-aerobic lagoons may result in a lower cost than either anaerobic or aerobic treatment separately.

III. DESCRIPTION OF PROCESSING PLANTS

The Simplot Burley Processing Company plant processes about 75,000 tons of potatoes per year. It is a highly automated processing plant and produces instant mashed potatoes and related specialties. The potatoes are washed, lye peeled, cut, automaticlly sorted for flakes or granules, dehydrated, and packed for shipment. Water use is about 1.2 mgd.

The J. R. Simplot Heyburn plant is one of the largest potato processing plants in the world. It processes approximately 180,000 tons per year and employs 860 people. Products include french fries, potato specialties, and potato starch. Here, too, the potatoes are washed and lye peeled; then trimmed, blanched, processed, and packed. Water use totals about 5.0 mgd.

Table 1 presents average figures for waste production per ton of potato processed as measured during the 1966-67 processing season. These figures do not include fat recovered or solids screened out for cattle feed. Unit waste production for this season, however, was higher than generally reported.

TABLE 1

WASTE PRODUCTION PER TON OF RAW POTATOES[a]
J. R. Simplot Co. - Burley, Idaho - 1966-67

Parameter	
BOD_5	92 lbs
COD_s	208 lbs
TVS	165 lbs
SS	106 lbs
SVS	105 lbs
Process Water	4,170 gal

(a) Based on the combined waste and total potato production at both plants.

IV. WASTE TREATMENT PLANT

A. Description

Waste streams from both potato processing plants are piped to a primary waste treatment plant. They first enter a receiving tank and are passed through two 5-foot diameter, 10-foot long rotary drum screens as shown in Figure 1. (All figures appear in Appendix D.) All solids retained on the +20 mesh screens are strained and stored in bins.

The remaining waste water then enters a 100-foot diameter Eimco clarifier with an overflow rate of about 800 gallons per day per square foot. Additional solids settle out in the clarifier and the overflow passes through a Parshall flume and is discharged to the Snake River.

The solids collected as clarifier underflow are pumped through a Sharples Super-D-Canter Dewatering Centrifuge. The sludge is stored in bins and the centrate is either returned to the clarifier or discharged to the river.

The screenings and the sludge from the centrifuge are trucked together to a cattle feet-lot operation for use as part of the animal's diet.

B. Efficiency

Primary treatment plant efficiency affects both the design and cost of secondary treatment. A high degree of efficiency requires a well-designed and operated primary clarification system. When this

is provided, the cost of secondary treatment is minimized.

The efficiency of the primary clarifier at the J. R. Simplot Co.'s Waste Treatment Plant is indicated by seasonal averages of the waste parameters measured on the clarifier influent and effluent during the January through May, 1967, processing period as shown in Table 2. All data is presented in Appendix B.

The influent temperature ranged from 68 to 82 degrees Fahrenheight and averaged 78. The temperature of the waste dropped an average of 4 degrees across the primary clarifier. BOD_5 reduction across the clarifier averaged 40 percent with an average effluent concentration of 1680 mg/l. COD_s was reduced by 45 percent and the suspended solids were reduced an average 73 percent. The suspended solids concentration in the clarifier effluent with a maximum 3190 mg/l, averaged 740 mg/l.

The influent to the primary clarifier contained an average total Kjeldahl nitrogen concentration of 113 mg/l as N and the effluent contained 78 mg/l. Thirty-one percent was removed by the primary clarifier. Only 10 percent of the phosphates were removed by the clarifier with the effluent containing 51 mg/l as PO_4.

TABLE 2

OPERATIONAL CHARACTERISTICS OF PRIMARY CLARIFIER[a]

		Clarifier Influent	Clarifier Effluent	Ave. Removal %
pH	Range	12.1 - 10.6	11.6 - 7.1	
	Median	11.3	10.4	---
Temp °F	Range	82 - 68	79 - 63	
	Mean	78	74	---
	Std. Deviation	± 3	± 3	
BOD_5 mg/l	Range	5150 - 1900	2080 - 1180	
	Mean	2780	1680	40
	Std. Deviation	± 750	± 200	
COD_S mg/l	Range	10,800 - 3120	6000 - 2520	
	Mean	6140	3400	45
	Std. Deviation	± 1720	± 610	
TS mg/l	Range	9080 - 3950	5970 - 2070	
	Mean	6440	4040	37
	Std. Deviation	± 1160	± 600	
TVS mg/l	Range	7410 - 2500	4300 - 1880	
	Mean	4850	2540	48
	Std. Deviation	± 1270	± 510	
SS mg/l	Range	5900 - 280	3190 - 90	
	Mean	2730	740	73
	Std. Deviation	± 1340	± 640	
VSS mg/l	Range	5900 - 280	3040 - 50	
	Mean	2680	640	76
	Std. Deviation	± 1330	± 570	

(a) J. R. Simplot Co. from January through May, 1967.

V. PILOT PLANTS

A. Description

The pilot plant facility of the Potato Processors of Idaho is located at the primary waste treatment plant in Burley, Idaho. Two earthen ponds sealed with concrete applied as gunite were utilized together with ancillary pumps and piping. Each pond was 40 feet square at the water surface and 10 feet deep with side slopes of 3 on 1; providing about 51,000 gallons capacity. Feed and overflow were at the water surface on opposite sides of the pond. Flows were measured by timing the filling of a bucket at the feet lines.

The anaerobic cell, pond II, was covered with 3-inch thick styrofoam blocks to retard heat loss and control odors. It was provided with a 100 gpm pump to continuously circulate the contents from the bottom to the inlet. Feed to the cell was pumped from the clarifier overflow at a predetermined flow rate.

The aerated cell, pond III, was pump fed from the surface of the anaerobic cell. Pond III contained a floating 5 hp Wells aerator and was open to the atmosphere. Figure 2 is a schematic diagram of the pilot plants as operated from January 2, 1967, to the end of the processing season.

B. Operation

Both ponds were placed in operation September 19, 1966 as covered anaerobic lagoons while awaiting the arrival of a previously ordered surface aerator. Inasmuch as the aerator was not delivered until the latter part of December, both ponds were operated as parallel

anaerobic units until the processing and waste treatment plants were shut down for the holidays, December 23, 1966. This period of pond operation was covered in a previous progress report.[2]

On January 2, 1967, both ponds were started as covered anaerobic units with the feed rates set at 1.15 gpm to pond II and 8.8 gpm to pond III. The feed to both ponds was clarifier effluent. Pond II was seeded with 20 gallons of primary sludge from a municipal sewage treatment plant on January 4. The styrofoam cover was removed from pond III on January 11 and on the following day the feed to pond III was changed from clarifier effluent to pond II effluent. The feed rate to pond III was 3.7 gpm, the minimum for that pump. This pump was operated intermittently since pond II was only being fed at a rate of 1.15 gpm. The feed rate to pond II was increased slowly until both ponds were being fed at the same rate on February 23.

The 5 hp Wells surface aerator was installed in pond III and started on January 14. At that time, with the ponds in series and the aerator running, the complete sampling program was started.

Eight-hour composite samples were collected from the clarifier influent and overflow. Grab samples were collected from the effluent of each pond. Split samples in iced containers were shipped by bus on a weekly schedule to the Idaho State Health Department laboratory and to the FWPCA Pacific Northwest Water Laboratory.

All analyses were performed according to the 12th edition of Standard Methods with the exception of volatile acids and the National Canner's Association modified chemical oxygen demand test (COD_m).[3] These are described in Appendix C. Tests included: pH, temperature, alkalinity, total dissolved organic carbon, volatile acids, solids, COD_s, COD_m, BOD_5, and inorganic nutrients. All data collected is presented in Appendix B.

Table 3 presents the feed rates and detention times for the three primary periods of operation of the two lagoons. Figure 3 presents the hydraulic loading rates for the entire period of January 2 to May 27, 1967.

TABLE 3

PILOT PLANT FEED RATES

	Pond II - Anaerobic		Pond III - Aerobic	
	Q	Detention Time		Detention Time
Date	gpm	Days	gpm	Days
2/23-3/20/67	4.0	8.8	4.0	8.8
3/29-4/23/67	7.0	5.0	7.0	5.0
4/30-5/27/67	15.0	2.4	15.0	2.4

C. Results

1. pH and Temperature

Fluctuations in pH in the primary clarifier effluent, anaerobic pond II effluent, and aerobic pond III effluent are presented

in Figure 4. The pH of the clarifier effluent ranged from 7.1 to 11.7 with a median of 10.7. During the three periods of study (Table 3), the median pH was 6.5, 6.4, and 6.5 in pond II effluent, respectively, and 8.3, 8.6, and 8.3 in pond III effluent.

The temperature drops across the primary clarifier, the clarifier plus pond II, and the clarifier plus ponds II and III are shown on Figure 5. Across the clarifier plus both ponds the temperature drop ranged from 45° F in late January to less than 25° F in May. During the three periods of operation the temperature averaged 62, 68, and 71° F in the anaerobic pond effluent, respectively, and 42, 43, and 53° F in aerobic pond III effluent.

2. Alkalinity and Volatile Acids

Although analyses for alkalinity and volatile acids were made on samples from all sampling points they are of primary concern only in the anaerobic cell, pond II. Volatile acids : alkalinity ratios in excess of 0.8[4] are inhibitory to methane production in anaerobic digestion. Figure 6 shows the change in volatile acids concentration and the volatile acids : alkalinity ratio during the study. The volatile acids ranged from 600 in January to 3500 mg/l in the middle of May. The volatile acids : alkalinity ratio ranged from 0.5 to 1.0 for the first two months, then it started increasing and reached a maximum of 3.5 on May 9. Since the primary aim was only hydrolysis of the wastes in the anaerobic pond to more easily oxidized forms, the high ratios and high volatile acids concentrations were probably not harmful.

3. Solids

Averaged reductions in suspended solids and total volatile solids for the three periods of operation are shown in Table 4. All reductions, both positive and negative, shown for the primary clarifier, anaerobic pond and aerobic pond are based on the percentage change from the influent to the effluent of that unit. Overall reductions show the percentage change from the influent of the primary clarifier to the effluent of the aerobic pond. BOD loadings were calculated from the feed rates and influent BOD_s to each of the two ponds.

During the February 23 to March 20 period the primary clarifier removed 57 percent of the suspended solids. The anaerobic pond reduced the suspended solids by 82 percent and there was a 230 percent increase in suspended solids upon passage through the aerobic pond. Overall reduction in suspended solids across the clarifier and both ponds was 74 percent.

Suspended solids removal by anaerobic pond II was related to the efficiency of the primary clarifier. As the percentage removal increased across the clarifier, the removal decreased across the anaerobic pond. Volatile suspended solids averaged 97 percent of the suspended solids for the clarifier influent, 90 percent for the clarifier effluent.

Total volatile solids reductions by ponds II and III are shown on Figure 7. Average reductions for the three periods

Table 4 BOD_5 Loadings and

Plant Efficiencies

Period	BOD_5 Loading lbs/1000 cu.ft./day	Reduction - %				
		BOD_5	COD_S	TDOC	SS	TVS
2/23/67 - 3/20						
Primary clarifier	--	41	23	--	57	36
Anaerobic pond	11	25	33	--	82	48
Aerobic pond	8	88	49	--	-230	23
Overall	--	95	73	--	74	74
3/29/67 - 4/23						
Primary clarifier	--	44	50	26	70	51
Anaerobic pond	22	12	15	2	35	29
Aerobic pond	20	87	58	38	-75	33
Overall	--	94	82	55	66	77
4/30/67 - 5/27						
Primary clarifier	--	41	47	18	69	62
Anaerobic pond	46	13	15	10	52	33
Aerobic pond	40	64	28	17	-226	12
Overall	--	81	68	39	51	66

ranged from 29 to 48 percent across pond II and from 12 to 33 percent across pond III. The negative reductions shown for pond III in January are a result of the change of operation from a covered anaerobic pond to an aerobic pond. While operating as an anaerobic unit a considerable buildup of suspended solids occurred in pond III. After conversion to an aerobic unit these solids were washed out, markedly influencing reductions for most of January.

The total volatile solids : total solids ratio remained fairly constant throughout the study for each of the sampling points as shown by the following table:

	Clarifier Influent	Clarifier Effluent	Pond II Effluent	Pond III Effluent
Range	0.59 to 0.82	0.56 to 0.89	0.36 to 0.89	0.36 to 0.59
Mean	0.72	0.63	0.52	0.45
Std.Dev.	$\pm$ 0.05	$\pm$ 0.06	$\pm$ 0.09	$\pm$ 0.06

4. COD_m

This test was a modification of National Canners Association's method[3] for running a quick COD test. For certain wastes it has been shown that a good correlation exists between COD_m and either COD_s or BOD. In this study both the COD_m : COD_s ratio and the COD_m : BOD ratio varied depending upon type of treatment as well as organic loadings. All COD_m data may be found in Appendix B, Table A-12.

5. COD_s

Figure 8 shows the COD_s loading and reductions by anaerobic pond II. In general the removals decreased from about 50 percent to

about 13 percent as the COD_s loading was increased from 10 to 100 lbs/day/1000 cu.ft. As the average BOD_5 loading was increased from 11 lbs/1000 cu.ft./day to 22 to 46 during the three separate periods of operation, the average COD_s reductions were 33, 15, and 15 percent, respectively.

COD_s reduction by pond III ranged from -50 percent, due to the changeover from anaerobic to aerobic, to 60 percent as shown in Figure 9. With a BOD_5 loading of 20 lbs/1000 cu.ft./day during the March 29 to April 23 period, the COD_s reduction averaged 58 percent. During the third period when the BOD_5 loading averaged 40 lbs, the average COD_s reduction dropped to 28 percent. After the COD_s loading increased above 60 lbs/day/1000 cu.ft., the percent reduction started to decrease rapidly. The total COD_s reduction across ponds II and III is shown in Figure 10 along with the reductions calculated from Idaho State Health Department's data. Agreement is good except for four samples during the month of April which showed consistently higher removals based on the Department's data.

Figure 11 shows all of the COD_s data run onsite for both ponds. The influence of loading is readily seen as removals decreased for both ponds with increasing load. Reduction by pond II appeared to reach a minimum of 10-15 percent as the loading was increased to the 50 to 110 lbs/day/1000 cu.ft. area. The drop in COD_s reductions across pond III was rather uniform as the loading was increased from

15 to 90 lbs/day/1000 cu.ft. The five low reductions near the 16 lb/day loading were a result of the change in operation of pond III from anaerobic to aerobic. Much of the scatter may be attributed to using grab samples from the pond effluent for analysis.

6. BOD_5

The BOD_5 loadings on and reductions by anaerobic pond II are shown in Figure 12. As the loading was increased from 4 to 50 lbs BOD_5/1000 cu.ft./day, the percent reduction decreased from 50 to about 10. For the three periods of operation shown in Table 3, the reduction averaged 25, 12, and 13 percent, respectively.

Figure 13 presents the BOD_5 reductions by aerobic pond III and the loadings on that pond. After the solids which had accumulated during operation as an anaerobic lagoon were washed out, the BOD_5 reduction maintained itself in the 80 to 90 percent range until the loading increased to about 20 lbs/1000 cu.ft./day. For the three periods of operation the reductions averaged 88, 87, and 64 percent as the loading was increased from 8 to 20 to 40 lbs BOD_5/1000 cu.ft./day.

Five-day BOD reductions across both ponds are shown in Figure 4 based on the data collected onsite and that collected by Idaho State Health Department. For the first two months of the study, the reductions based on the Health Department's data were 30 to 40 percent lower than those based on analyses run onsite. Some of this disagreement may be explained by the fact that the State Health Department seeded their incubation bottles and the BOD's run onsite were not seeded. In

addition, different techniques were used for getting the small sample sizes needed for the high BOD's encountered. As the study progressed the differences between the two labs decreased. BOD_5 reductions across the two ponds were maintained near 85 percent for about three months.

A plot of percent reduction vs BOD loading in lb/day/1000 cu.ft. for both ponds is shown in Figure 15. Estimated lines of best fit were drawn through the data and these curves were used for a rough cost comparison between anaerobic and aerobic ponds. This is discussed later.

7. Total Dissolved Organic Carbon

Nine sets of samples were analyzed for total dissolved organic carbon (TDOC) during the April and May period of operation. The primary clarifier reduced the TDOC from an average of 1590 to 1220 mg/l (23 percent). The results from the ponds are shown in the following table:

Date	Pond II Influent	Pond II Effluent	Pond III Effluent
3/29-4/23	1250	1220	755
4/30-5/27	1230	1090	915

Removal across both ponds averaged 40 percent during the 3/29 to 4/23 period and 26 percent during the May period.

8. Inorganic Nutrients

Inorganic nutrient levels were measured in the form of total phosphate, ammonia nitrogen, nitrite and nitrate nitrogen, and total Kjeldahl nitrogen. Neither phosphates nor nitrogen were removed by the ponds as expected, inasmuch as both ponds were completely mixed. The nitrogen form changed upon passage through both ponds. Ninety-one percent of the 78 mg/l total Kjeldahl nitrogen was in the organic form

in the clarifier effluent. In the effluent from the anaerobic pond only 42 percent of the nitrogen was in the organic form and the percentage increased to 78 upon passage through pond III.

The feed to pond III contained about 75 mg/l total Kjeldahl nitrogen, 50 mg/l phosphate, and 1500 mg/l of BOD_5. These values result in a BOD : N ratio of 20:1 and a BOD : P ratio of 90:1. The most commonly quoted ratios for N and P requirements of aerobic biological systems are 20:1 and 100:1. Based on the measured levels of inorganic nutrients and the degree of treatment obtained by the ponds, nutrient deficiencies did not seem to occur.

VI. PRELIMINARY COST ESTIMATE

The loading curves drawn on Figure 15 were used to make some very rough cost estimates to see if a combination anaerobic-aerobic system might result in lower total annual charges. The following assumptions and prices were used to develop the cost estimates.

1. BOD of clarifier influent = 2700 mg/l.
2. BOD of clarifier effluent = 1700 mg/l. (Thirty-seven percent reduction by clarifier.)
3. Overall BOD_5 reduction = 90% (effluent BOD = 270 mg/l).
4. Aerators installed at $500/HP (amortized across 10 years at 6 percent).
5. Cost of aerator maintenance at 2%/year of installed cost.
6. Aerators add 2 lbs O_2/HP-hr.
7. Oxygen requirements of waste = 1.2 lbs/lb BOD applied.
8. Power costs $0.01/KW-Hr.
9. Total land costs based on $1000/acre of lagoon surface (yearly cost of 6%).
10. Aerobic ponds installed (lined) at $10,000/acre (10 years - 6%).
11. Anaerobic ponds installed (lined, covered, and mixed) at $16,000/acre (10 years - 6%).
12. Waste plant operates 300 days/year, 24 hours/day.

A series of annual charges were calculated using these assumptions for various combinations of anaerobic-aerobic loadings to achieve the

effluent BOD_5 concentration of 270 mg/l. Other costs were assumed to remain relatively constant for a given size plant regardless of type of treatment used. On Figure 16 is shown the annual charges in $1,000/yr/mgd treated. Any combination of anaerobic reduction and aerobic reduction, shown directly opposite will reduce the BOD from 1700 to 270 mg/l. Arriving at the desired endpoint by aerobic ponds only (84% reduction) results in a cost of about $48,000/year per mgd treated, whereas, anaerobic ponds removing 35% of its influent BOD followed by aerobic ponds reducing it to 270 mg/l results in a cost of about $39,000. The important point from this preliminary analysis is that a combination anaerobic-aerobic system appears at this time to result in an overall cost lower than either of them separately. This is true despite the relatively poor BOD removals obtained by the anaerobic pond and the higher installed cost of anaerobic ponds.

VII. DISCUSSION

The pilot plant study on secondary treatment of potato processing wastes will be continued during the 1967-68 processing season. Due to the late arrival of the 5 hp aerator the anaerobic-aerobic lagoons in series were only operated about one-half of the 1966-67 season. The 10-hp aerator for a third aerobic lagoon which was to be operated in parallel with the other two ponds did not arrive until the end of the processing season. Preliminary conclusions, however, may be drawn from the data already collected and presented in this report.

An overall BOD_5 reduction of at least 90 percent is feasible with primary clarification followed by anaerobic and aerobic ponds in series. Preliminary findings indicate that loading rates in the range of 10 to 20 pounds of BOD_5 per 1000 cu.ft./day can be applied to the lagoons to achieve the desired removals. The BOD_5 removal varied from 12 to 25 percent across the anaerobic pond and from 87 to 88 percent across the aerated pond at these loading rates. Overall pilot plant efficiencies during this period ranged from 88 to 91 percent BOD removal. Coupled with an average of 40 percent removal by the primary plant, this results in a total BOD removal in excess of 90 percent.

The combination of high BOD removals with substantial increases in suspended solids across the aerobic lagoon indicate that inorganic

nutrient levels were not limiting to growth of required organisms to accomplish treatment. As a result of this solids increase, the overall suspended solids reduction was relatively poor -- ranging from 50 to 75 percent. In order to increase the suspended solids reduction to 90 percent or higher, secondary clarification will be needed. This would also increase the overall BOD removals.

The advance of the volatile acids : alkalinity ratio above 0.8 did not seem to affect the removal rates in the anaerobic pond. Short detention time coupled with pH values of about 6.5 and fluctuating loading conditions contributed to the inhibition of methane production. The purpose of the anaerobic cell was to carry out the first stage of anaerobic fermentation and hydrolize some of the more complex organics to simpler forms more amenable to aeration. The effectiveness of this cell cannot be evaluated until results from a parallel aerobic lagoon study are obtained. Mixing the contents and covering the anaerobic pond with styrofoam did, however, increase its effectiveress by holding the temperature drop to a minimum and preventing sludge deposits from accumulating in the pond.

Foaming in the aerated cell was an intermittent problem. At the small scale of our pilot lagoon it was not a major nuisance, but a fullscale lagoon will probably require some means of preventing foaming.

The cost analysis presented is based on rough assumptions and the annual charges derived from it are subject to gross adjustment. The figures do, however, provide an idea of the relative weight to be applied to removals in the anaerobic or aerated cells.

The 1967-68 processing season should provide all the necessary additional pilot plant data for formulation of design parameters for lagooning potato wastes. Changes planned for the pilot facility will greatly expedite its operation. In addition, the replacement of the primary sludge centrifuge with a vacuum filter will substantially reduce the solids loading to the ponds and should result in even better removal rates.

VIII. REFERENCES

1. "Idaho Image," Idaho State Department of Commerce and Development, Boise, Idaho. July 1967.

2. "Progress Report - Pilot Plant Studies on Secondary Treatment of Potato Process Water", Federal Water Pollution Control Administration, Northwest Region, Corvallis, Oregon, January 1967.

3. Rose, W. W. and W. A. Mercer. "Chemical Oxygen Demand as a Test of Strength of Cannery Waste Water." National Canners Association Research Laboratories, Berkeley, California, May 16, 1956.

4. "Anaerobic Sludge Digestion," Journal Water Pollution Control Federation, p. 1684, October 1966.

5. DiLallo, R. and O. E. Albertson. "Volatile Acids by Direct Titration," Journal Water Pollution Control Federation, p. 356, April 1961.

6. "An Engineering Report on Pilot Plant Studies, Secondary Treatment of Potato Process Water." Cornell, Howland, Hayes, and Merryfield, Boise, Idaho. September 1966.

IX. APPENDIX

APPENDIX A

Memorandum of Understanding

MEMORANDUM OF UNDERSTANDING

This agreement sets forth the provisions of a cooperative study of methods for secondary treatment of potato processing wastes to be conducted by the Pacific Northwest Water Laboratory, (a division of the Federal Water Pollution Control Administration), the Potato Processors of Idaho Association, and the Idaho Department of Health.

Objective: This project will conclude pilot plant studies on feasible methods of secondary treatment of potato processing wastes.

Facilities: These studies will be conducted on pilot plant facilities furnished by the J. R. Simplot Co. at its Burley, Idaho, site. This company has constructed three lined cells, each 40 feet square, and about 10 feet deep with a liquid volume of 51,000 gallons, which receives the clarified effluent from two integrated potato processing plants. Some pilot plant studies were made on these facilities last year and operating data are available. Major laboratory equipment and supplies will be furnished by FWPCA.

FWPCA Responsibility: Technical assistance will be provided consisting of one resident sanitary engineer on site during the 1966-67 processing season to supervise and operate pilot plant facilities, determine plant loadings and flow patterns, and perform laboratory tests. General supervision and laboratory back up will be provided by FWPCA through the Pacific Northwest Water Laboratory at Corvallis, Oregon.

State Responsibility: The State of Idaho will provide some laboratory staff and facilities for special analyses requiring more than routine type equipment.

Industry Responsibility: The industry will provide some laboratory space and pilot plant facilities as well as some assistance in routine plant operation. Some existing laboratory equipment will be provided. Plant production figures will be made available for calculation of unit loads on the pilot plant facilities.

Procedure: Sufficient chemical and bacteriological analyses at various flows and organic loadings will be run to determine the feasibility of secondary treatment methods. Treatment processes to be studied include: (1) anaerobic treatment in one cell equipped with a Styrofoam float cover followed by aerobic treatment in a mechanically-aerated pond, and (2) independent aerobic treatment in an additional mechanically-aerated pond.

Coordination: Day-to-day direction of pilot plant operation and tests will be provided by FWPCA. Regular review meetings will be held at intervals of approximately one month to apprise State and industry representatives of study findings and to review proposed operation and tests.

Reports: Semimonthly activity reports will be prepared by FWPCA and submitted to the State and industry representatives. At the completion of the processing season, in the spring of 1967, all pilot plant study results shall be incorporated into a final report prepared by FWPCA for public distribution, which shall include unit waste loadings and a description of the process wastes being treated.

Revision and Termination: Changes in the provisions of this agreement may be made by mutual consent of the parties thereto. This agreement shall terminate on December 31, 1967.

For the FEDERAL WATER POLLUTION CONTROL ADMINISTRATION:

James R Bryden — Date: Jan 9, 1967

Director, Technical Services
Pacific Northwest Water Laboratory

For the IDAHO DEPARTMENT OF HEALTH:

Harlan H. Jones — Date: Jan. 3, 1967

Chief, Water Pollution Section

For the POTATO PROCESSORS OF IDAHO ASSOCIATION:

Ray W. Kunsman — Date: Dec 29, 1966

Vice President, J. R. Simplot Co.

APPENDIX B

Data

Table A-1 FLOW DATA, gpm

Date	Clarifier	Aerobic Pond I	Anaerobic Pond II	Anaerobic Pond III	Comments
1-1-67			1.2	8.8	Ponds down since 12-23-66
2			1.2	8.8	
3	3510		1.2	8.8	
4	3880		1.2	8.8	
5	4220		1.2	8.8	
6	3750		1.2	8.8	
7	3690		1.2	8.8	
8	3380		1.2	8.8	
9			1.2	8.8	
10			1.2	8.8	
11			1.2	8.8	
12			1.2	3.7	→ Changed pond III to aerobic in series following pond II. Pump minimum = 3.7 gpm.
13			1.2	3.7	
14			1.2	3.7	
15	3320		1.2	3.7	
16	4220		1.2	3.7	
17	4220		1.2	3.7	
18	4390		1.2	3.7	
19	4190		1.2	3.7	
20	4220		1.7	3.7	
21	4210		2.0	3.7	
22	4280		2.0	4.0	
23	4390		2.0	4.0	
24	4220		2.3	4.0	
25	4220		2.8	4.0	
26	4390		2.8	4.0	
27	4390		3.0	4.0	
28	4220		3.0	4.0	
29					
30	4390		3.0	4.0	
31	4390		3.2	4.0	
2-1	4390		3.2	4.0	
2	4190		3.2	4.0	
3	4390		3.2	4.0	
4	3500		3.2	4.0	
5					
6	4390		3.2	4.0	
7	4390		3.2	4.0	
8	4390		3.5	4.0	
9	4290		3.5	4.0	
10	4290		3.5	4.0	
11	4040		3.5	4.0	
12					
13	4380		3.5	4.0	
14	4390		3.5	4.0	

Table A-1 FLOW DATA (Cont'd.)

Date	Clarifier	Aerobic Pond I	Anaerobic Pond II	Anaerobic Pond III	Comments
2-15	4390		3.5	4.0	
16	4390		3.5	4.0	
17	4290		3.8	4.0	
18	3760		3.8	4.0	
19			3.8		
20	4290		3.8	4.0	
21	4390		3.8	4.0	
22	4390		3.8	4.0	
23	4390		3.8	4.0	
24	4220		4.0	4.0	
25	4170		4.0	4.0	
26					
27	4190		4.0	4.0	
28	4190		4	4	
3-1	4290		4	4	
2	4290		4	4	
3	4390		4	4	
4	4190		4	4	
5					
6	4290		4	4	
7	4390		4	4	
8	4290		4	4	
9	4390		4	4	
10	4390		4	4	
11	3860		4	4	
12					
13	4390		4	4	
14	4390		4	4	
15	4390		4	4	
16	4390		4	4	
17	4390		4	4	
18	4290		4	4	
19					
20	4390		4	4	
21	4390		5	5	
22	4390		5	5	
23	4390		6	6	
24	4390		6	6	
25	3590		6	6	
26					
27	4390		6	6	
28	4390		6	6	
29	4390		6	6	
30	4390		7	7	
31	4390		7	7	

Table A-1 FLOW DATA (Cont'd.)

Date	Clarifier	Aerobic Pond I	Anaerobic Pond II	Anaerobic Pond III	Comments
4-1	4060		7	7	
2					
33	4390		7	7	
4	4390		7	7	
5	4390		7	7	
6	4390		7	7	
7	4390		7	7	
8	4390		7	7	
9					
10	4220		7	7	
11	4390		7	7	
12	4390		7	7	
13	4390		7	7	
14	4390		7	7	
15	4040		7	7	
16					
17	4390		7	7	
18	4390		7	7	
19	4390		7	7	
20	4290		7	7	
21	4220		7	7	
22	4140		7	7	
23					
24	4390		9	9	
25	4390		9	9	
26	4390		11	11	
27	4390		11	11	
28	4220		13	13	
29	4190		13	13	
30					
5-1	4390		15	13	
2	4390		15	15	
3	4390		15	15	
4	4390		15	15	
5	4390		15	15	
6	4390		15	15	
7					
8	4390		15	15	
9	4390		15	15	
10	4390		15	15	
11	4390		15	15	
12	4290		15	15	
13	4210		15	15	
14					
15	4390		15	15	
16	4390		15	15	
17	4390	7	15	15	Started aerobic Pond I

Table A-1 FLOW DATA (Cont'd.)

Date	Clarifier	Aerobic Pond I	Anaerobic Pond II	Anaerobic Pond III	Comments
5-18	4390	7	15	15	
19	4390	7	15	15	
20	4390	7	15	15	
21	4390	7	15	15	
22	4390	7	15	15	
23	4390	7	15	15	
24	4390	7	15	15	
25	4390	7	15	15	
26	4390	7	15	15	
27	4390	7	15	15	

Table A-2 TEMPERATURE DATA, °F

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
1-3-67	73	63		52	54
4	73	69		52	58
5	72	70		52	58
6	74	70		54	59
7	73	69		51	51
9	73	69		55	50
10	80	74		54	47
11	78	71		55	44
12	76	73		54	44
13	80	76		54	44
14				53	44
16	77	70		56	34
17	77	73		54	32
18	76	72		55	32
19	78	74		55	33
20	78	76		54	36
21	77	73		54	36
23	78	74		56	34
24	80	76		56	32
25	77	75		56	33
26	79	75		57	33
27	78	76		57	36
30	71	68		58	40
31	78	76		60	41
2-1	77	75		59	41
2	82	79			
6	72	69		53	35
7	79	76		59	35
8	77	76		58	33
9	78	76		61	38
10	80	75		60	38
11	78	75			
14	79	75		60	42
15	78	75		59	34
16	78	74			
17	78	74		61	34
20	77	75		62	34
21	77	74		60	33
22	80	76		60	34
23	79	75		63	37
24	78	74		62	43
25	78	73		60	41
28	77	74		61	39
3-1	78	75		62	42
2	78	74		59	43
3	77	75		61	46

Table A-2 TEMPERATURE DATA (Cont'd.)

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
3-4-67	78	74		62	45
6	70	69		53	36
7	78	74		61	32
8	78	74		63	35
9	78	74			
10	80	76		62	48
11	79	76			
13	78	76		60	42
14	79	76		61	39
15	77	75		65	41
16	78	75			
17	78	76		65	51
18	79	77		66	49
20	78	76		63	48
21	81	76		64	44
22	82	79		66	46
23	82	77			
24	81	76			
27	72	70			
28	79	77		66	47
29	78	76		67	40
30	78	75			
31	78	74		65	47
4-3	70	68			
4	79	77		67	40
7	80	77		66	41
11	78	73		68	42
13	79	77		70	47
18	80	78		70	42
19	79	75			
20	80	77		68	45
21	76	74			
24	68	64		63	44
25	79	77		67	44
27	77	75		68	44
5-2	76	72		68	40
3	76	72		70	46
9	82	80		73	57
11	79	77		71	51
15	68	66			
16	79	77		71	54
17	81	78		70	53
18	79	77	61	71	55
19	79	76			
20	80	76			
22	76	74	62	72	62

Table A-2 TEMPERATURE DATA (Cont'd.)

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
5-23-67	78	76			
24	79	76			
25	80	75	59	73	59
26	79	75			
27	78	76			

Table A-3 pH DATA

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
1-3-67	11.1	10.3		6.7	6.8
4				7.5	7.2
5	11.6	11.0		7.1	6.8
6				7.0	7.1
7				6.9	7.0
9				7.0	7.1
10				7.1	7.1
11				6.9	7.2
12	11.8	10.8		7.1	7.0
13				7.1	7.2
14				7.5	7.2
16				6.9	8.5
17	11.4	10.8		6.8	8.4
18				7.2	7.6
19	11.6	10.7		6.4	8.2
20				6.8	7.8
21				6.8	8.0
23				6.9	8.6
24	11.8	9.6		6.6	8.5
25				6.7	8.7
26	11.4	10.7		6.2	8.4
27				6.3	8.1
30				6.6	8.3
31				6.6	8.5
2-1				6.7	8.3
2	11.9	11.1		6.9	
6				6.7	8.7
7				6.7	8.3
8				6.4	8.5
9				6.5	8.3
10				6.4	8.4
14				6.4	7.6
15				6.6	7.8
17	10.7	8.9		6.3	8.5
20	10.8	10.7		6.3	8.4
21	11.1	10.3		6.6	8.6
22				6.2	7.5
23				6.6	8.1
24	11.5	11.4		6.6	8.2
25				6.5	8.0
28	11.2	10.9		6.3	8.3
3-1				6.4	8.3
2				6.5	8.3
3	11.1	10.3		6.3	7.9
4				6.4	8.2
6				6.5	8.9

Table A-3 pH DATA (Cont'd.)

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
3-7-67	11.3	10.6		6.6	8.9
8				6.6	8.5
10	11.4	10.2		6.6	8.4
13	12.1	11.6		6.6	8.5
14				6.5	8.4
15				6.6	8.3
17	11.4	9.4		6.6	8.2
18				6.6	8.3
20	11.4	9.9		6.3	8.2
21	10.8	11.1		6.4	8.3
22				6.4	8.2
28	11.6	10.1		6.8	8.3
31	10.6	8.9		6.5	8.6
4-4	11.6	10.1		6.4	8.5
7	10.8	10.1		6.3	8.6
11	10.5	10.0		6.3	8.5
13	11.4	10.8		6.3	8.4
18	11.1	11.2		6.7	8.5
20	11.2	7.1		6.4	9.0
25	11.6	10.5		6.4	8.0
27	11.7	11.1		7.0	8.1
5-2				6.6	8.4
3	11.3	10.8		6.6	8.1
9	11.4	11.7		6.5	8.2
11	11.4	10.8		6.5	8.2
16	11.2	9.8		6.2	8.3
17				6.4	8.2
18	11.5	10.4	8.0	6.3	8.3
22			8.6	6.6	8.4
25	11.5	11.2	8.2	6.6	8.4

TABLE A-4 TOTAL ALKALINITY DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
1-3-67	870	470		1100	1060
5	1230	930		1040	1100
12	1380	760		1090	1100
17	1070	860		1080	1120
19	1240	880		1010	1080
24	1500	810		1080	1160
26	1300	1060		1060	1140
31	1240	980		1080	1210
2-2-67	1810	1560		1160	
10	970	760		1070	1240
17	840	520		1080	1320
21	910	750		1000	1250
24	1180	1410		1040	1220
28	930	960		1080	1240
3-3-67	840	760		1020	1200
10	1030	780		1090	1210
17	1220	640		1020	1240
21	900	980		1080	1340
28	1110	610		1090	1320
31	820	450		990	1240
4-11-67	920	800		920	1210
13	970	880		980	1230
18	970	830		1010	1200
20	770	370		1040	1250
25	1050	700		940	1200
27	1200	1020		1010	1220
5-3-67	930	790		1050	1220
9	970	1130		1010	1240
16	1040	720		830	1210
25	1170	1020	1190	1020	1140

TABLE A-5 VOLATILE ACIDS DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
1-17-67	550	120		570	750
19	390	380		630	630
24	380	560		600	50
26	440	480		800	60
31	440	380		860	60
2-2-67	540	550		840	--
10	360	450		880	110
17	480	700		1040	540
21	340	300		1080	130
24	510	580		1040	140
28	380	420		1050	60
3-3-67	300	400		940	50
10	400	640		1200	90
17	450	720		1080	80
21	390	390		1230	60
28	420	640		1170	60
31	380	600		1590	60
4-11-67	380	420		1320	80
13	520	500		1620	540
18	940	800		2060	100
20	690	1300		2360	120
25	870	1040		2280	110
27	820	990		2320	120
5-3-67	760	860		2100	90
9	1950	2120		3520	100
16	1260	1170		2380	150
25	870	940	120	2180	300

TABLE A-6 TOTAL SOLIDS DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
1-3-67	5450	2070		2560	2720
4	7650	4660		2720	2690
5	7540	4160		2550	2580
10	8810	4000		2450	2910
12	8040	3480		2530	2930
17	5760	3360		2340	3350
19	6460	3880		2570	3050
24	7670	5090		2620	2140
26	6940	4710		3040	2810
31	6540	3900		2840	2750
2-7-67	6050	4100		2840	2630
14	6250	4010		2670	2540
15	5270	3630		2940	2390
21	4890	3430		2950	2860
22	4890	4330		2760	2700
28	5350	4050		3150	2860
3-2-67	7080	5970		2880	2630
7	6010	4410		2980	2690
8	3950	3500		2950	2710
14	6720	4300		2990	2780
15	8310	3480		3060	2780
21	6680	4080		3160	2640
22	6610	3940		3190	2690
28	6310	3750		3230	2830
29	9080	4070		3260	2800
4-4-67	6110	3870		3110	2870
7	6650	4080		3320	2950
11	6600	3700		3220	2770
13	6100	4370		3310	2770
18	6460	3880		3350	2730
20	5170	3750		3380	2820
25	6510	3880		3000	2750
27	6730	4270		3320	2810
5-3-67	6270	3800		3260	2880
9	8910	4750		3300	3190
11	4620	4680		3500	--
16	5900	3770		3010	2930
18	4680	4830	3290	3240	3360
22	5960	3310	2760	3090	3350
25	6580	4240	2500	3110	3270

TABLE A-7 CENTRIFUGED TOTAL SOLIDS DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent
1-4-67	4570	4020
17	3310	2940
31	4380	3630
2-21-67	3360	2850
28	3290	3810
3-7-67	3850	3300
14	4720	2090
21	3730	3230
28	4090	3600
4-4-67	3940	3840
11	3490	3390
18	4190	3670
25	3930	3490
5-3-67	3340	3390
9	4880	4670
16	3480	3660

TABLE A-8 SLUDGE-TOTAL SOLIDS DATA, mg/l

Date	Clarifier Influent	Sludge from Clarifier	Centrifuge Supernatant	Sludge from Centrifuge
1-4-67	7500	40,800	21,600	165,000
17	5590	81,800	40,300	184,000
24	6230	77,000	49,300	191,000
31	5930	50,500	32,500	203,000
2-14-67	6300	57,500	34,700	198,000
21	4380	61,000	29,800	210,000
28	4650	43,700	25,500	183,000
3-7-67	5190	44,500	23,200	208,000
14	5910	45,800	24,500	212,000
21	4920	36,100	32,800	218,000
28	5820	43,300	22,900	196,000
4-4-67	4050	40,400	24,300	227,000
11	5550	43,200	21,500	229,000
18	6230	45,800	26,500	191,000
25	4050	41,600	25,900	182,000
5-3-67	3950	63,500	28,200	241,000
9	6440	51,400	26,400	232,000
16	4860	48,800	23,900	182,000

TABLE A-9 TOTAL VOLATILE SOLIDS DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent	
1-10-67	6880	3480		1160	1460	
12	6030	2110		1200	1500	
17	3980	1880		880	1430	
19	4450	2260		930	1480	
24	5210	--		1240	1270	
26	5330	3080		1820	1660	
2-14-67	4510	2530		2380	1090	
15	3850	2340		1740	1130	
22	3510	2480		1380	1070	
3-2-67	4630	4300		1370	1050	
8	2500	2050		1460	1240	
15	6580	2240		1580	1090	
22	4900	2370		1650	1030	
29	7410	2730		1530	1200	
4-4-67	4150	--		1410	1110	
7	4970	2480		1890	1280	
11	4900	2150		1830	1170	
18	4460	2320		1750	1060	
20	3790	2420		1840	1020	1040(a)
25	4670	2340		1540	1010	
27	4790	2630		1840	1380	
5-3-67	4670	2280		1530	1080	
9	7200	2990		1900	1640	
11	3000	2750		1750	--	
16	4090	2190		1590	1260	
18	2750	3140	1490	1710	1580	
22	4520	2010	1090	1730	1730	
25	4810	2640	990	1850	1700	

(a) After 2 hours settling

TABLE A-10 SUSPENDED SOLIDS DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
1-3-67	1660	420		640	160
5	4040	2260		1140	100
12	5100	360		240	400
17		200		520	2060
19	3280	520		640	210
24	4140	1780		320	890
26	5900	680		1270	910
31	4500	600		870	650
2-15-67	2880	780		70	160
22	3280	510		390	950
3-2-67	2330	3190		370	830
8	2560	500		180	1100
15	5000	560		220	610
22	3170	860		370	1220
29	2600	1100		150	420
4-4-67	2380	990		380	460
7	2280	280		170	460
11	2580	420		250	740
13	280	820		400	1840
18	580	370		580	500
20	2700	90		720	200
25	2620	180		440	160
27	1660	400		1080	800
5-3-67	2020	500		500	280
9	2960	1160		910	1680
11	1280	500		80	120
16	2720	340		90	1160
18	3240	380	380	210	420
22	860	570	900	130	1080
25	720	840	480	130	1960

TABLE A-11 VOLATILE SUSPENDED SOLIDS DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
1-12-67	5060	400		140	400
17	3380	240		260	580
19	3280	520		370	210
24	4140	1780		230	830
26	5900	680		500	880
31	4440	600		470	590
2-15-67	2800	710		70	160
22	3280	510		390	890
3-2-67	2220	3040		340	700
8	2460	480		180	820
15	4780	500		200	560
22	2640	250		300	850
29	2680	1080		110	320
4-4-67	2320	990		380	460
7	2240	220		140	380
11	2480	420		230	740
13	280	770		230	1840
18	580	320		550	500
20	2580	50		--	80
25	2460	170		360	160
27	1580	360		730	640
5-3-67	2020	460		380	280
9	2920	960		730	1440
11	1120	460		80	120
16	2600	340		90	1020
18	3240	380	280	210	420
22	860	570	700	130	1080
25	660	620	240	60	1540

TABLE A-12 COD_m DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
1-4-67	6320	2780		540	690
10	3500	2020		500	660
13	2960	1300		620	1020
17	3180	1240		560	840
20	5680	2440		500	830
24	4740	2160		600	920
27	3720	3000		860	920
31	3820	1900		860	740
2-3-67	3900	2200		700	600
7	5680	1340		120	480
10	3040	1920		760	440
14	4400	2260		850	460
15	3940	1760		670	410
21	2600	1900		590	730
22	3380	2260		700	610
28	3220	2120		780	760
3-2-67	5280	4880		740	610
7	3080	2080		620	620
14	4500	2320		640	730
15	6580	4280		740	760
21	2820	2180		720	590
22	5440	2000		740	710
28	4240	2220		880	860
29	4440	1620		490	550
4-4-67	5220	2460		840	920
11	6120	2120		720	610
18	4300	2340		620	580
25	3640	2280		660	580
5-3-67	6920	1980		1170	960
9	6700	2460		860	950
16	2920	2440		700	680
22	2460	1720	810	870	1080

TABLE A-13 COD_s DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent	
1-4-67	7050	3740		1780	2150	
6	6390	3330		1580	2220	
11	5250	3360		1610	2300	
13	6540	3040		1640	2270	
16	4950	2660		1800	2740	
18	4860	2520		1460	2640	
20	6080	3600		1640	2480	
23	8100	3700		1890	1930	
25	4920	3720		2000	1990	
27	5920	4090		2340	1680	
30	4110	2680		2330	1590	
2-1-67	5900	3150		2240	1450	
3	5140	4030		2210	1660	
10	3700	2680		2330	790	
15	3140	3140		2190	960	
22	9860	3440		2190	2020	
3-2-67	5660	6000		2520	1340	
8	3120	2930		2500	1250	
15	--	2930		2500	1410	
22	6050	3330		2680	1230	690(a)
29	7270	3790		2840	1170	680(b)
4-4-67	6940	3550		2760	1180	710(a)
7	6880	3320		2930	1170	
11	6940	3000		3080	1220	710(a)
13	7440	3530		3140	1360	
18	7260	3170		2620	1270	
20	4980	3360		2890	1150	870(b)
25	7200	3280		2810	1530	
27	7240	3230		2810	1190	
5-3-67	6750	3180		2750	1530	
9	10800	3870		3310	2520	
11	4140	3790		3270	1920	
16	5920	3030		2660	1940	
18	9570	4100	1400	2750	1980	
22	3420	2730	1320	2990	2050	
25	4650	3080	1290	2470	2570	

(a) After 5 minutes centrifuging
(b) After 2 hours settling

TABLE A-14 BOD DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
1-4-67	2580	1680		670	950
11	2550	1800		950	1290
18	2210	1180		730	1170
25	2630	1830		1020	280
2-15-67	2180	1710		1200	250
22	2050	1800		1070	230
3-2-67	2260	1870		1100	120
8	1900	1220		1110	120
15	3720	1550		1260	180
22	2340	1630		1180	220
29	3800	1510		1060	100
4-7-67	3060	1750		1420	95
11	3080	1550		1730	200
13	3100	1720		1700	240
18	3100	1770		1560	320
20	2350	1960		1580	240
27	3170	1690		1440	340
5-3-67	2280	1590		1590	320
9	5150	2000		1590	570
11	1930	2080		1710	540
16	3160	1680		1350	640
18	3650	1480	540	1390	640
22	2200	1660	360	1630	640
25	2200	1720	420	1390	790

Table A-15 AMMONIA NITROGEN DATA, mg/l as N

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
3-16-67	7.5	5.5		48	14
23	5.3	4.0		25	18
29	9.1	6.1		36	30
4-4	7.1	7.7		45	26
11	6.1	5.4		39	21
19	9.8	7.8		35	23
25	6.4	5.9		47	24
5-3	8.2	7.0		29	11
10	10.0	9.3		88	10
16	9.6	9.5		28	19
23	10.8	8.9	27	43	--
mean	8.2	7.0		43	20

NITRATE-NITROGEN DATA, mg/l as N

3-16-67	1.0	0.7		0.2	0.5
23	1.1	1.0		0.2	0.3
29	0.6	1.2		0.5	0.2
4-4	1.4	1.5		0.3	0.6
11	1.7	1.4		0.1	0.1
mean	1.2	1.2		0.3	0.3

NITRITE-NITROGEN DATA, mg/l as N

3-16-67	0.2	0.2		0.03	0.04
23	0.2	0.1		0.02	0.03
29	0.2	0.1		0.02	0.02
4-4	0.2	0.1		0.13	0.05
11	0.3	0.2		0.03	0.004
mean	0.2	0.1		0.05	0.03

Table A-16 TOTAL KJELDAHL NITROGEN DATA
mg/l as N

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent	
3-16-67	225	38		41	20	
23	96	83		87	91	
29	131	72		79	92	
4-4	112	108		79	79	
11	91	60		70	86	
19	110	99		70	89	
25	102	84		79	91	
5-3	76	48		69	90	
10	120	93		87	110	
16	93	70		67	104	
23	84	98	79	85	130	
mean	113	78		74	89	
		7		43	20	NH_3
		71		31	69	Org.

Table 1-17 TOTAL PHOSPHATE DATA

mg/l as PO_4

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
3-16-67	46	71		51	53
23	63	46		52	52
29	89	50		55	57
4-4	33	41		24	26
11	52	41		39	56
19	60	45		50	54
25	57	48		53	55
5-3	46	36		53	54
10	67	64		56	62
16	71	64		62	73
23	45	48		52	65
mean	57	51		50	55
		ORTHO-PO_4			
5-23	11.7	3.8		19.0	9.7

Table A-18 TOTAL ORGANIC CARBON DATA, mg/l

Date	Clarifier Influent	Clarifier Effluent	Pond I Effluent	Pond II Effluent	Pond III Effluent
3-29-67	1720	1350		1240	860
4-4	1550	1350		1200	730
11	2020	1220		1370	870
19	1420	1070		1060	560
25	1610	1110		1040	810
5-3	1190	1090		1170	890
10	1760	1340		1150	950
16	2080	1200		1000	890
23	980	1290	730	1040	930
mean	1590	1220		1140	830

Table A-19 IDAHO STATE HEALTH DEPARTMENT DATA (a)

	pH	Total Alkalinity	Total Solids	Suspended Solids	COD	BOD
1-11-67						
Clarifier Influent		1295	5468	506	3998	2150
Clarifier Effluent		725	3933	393	3644	1862
Pond II Effluent		1130	3831	327	2118	1088
Pond III Effluent		1090	3801	382	2451	1270
1-1[illegible]						
Influent	10.6	920	5834	2100	3493	2314
Effluent	10.5	930	3791	620	3089	1818
Pond II	6.6	1110	2756	200	1680	1202
Pond III	8.0	1040	3599	740	2378	2285
1-25						
Influent	11.9	1080	5780	500	3738	3900
Effluent	8.0	490	3901	464	3224	2010
Pond II	7.6	1060	3214	316	1950	1140
Pond III	9.2	1380	3396	576	1416	1260
2-1						
Influent	11.4	1570	8946	610	7558	3137
Effluent	11.2	1120	5005	180	3184	1758
Pond II	6.7	1090	3173	120	2336	1223
Pond III	8.2	1450	2822	200	1638	1544
2-8						
Influent	10.8	1130	7335	288	10691	5450
Effluent	10.2	960	4164	204	3933	2812
Pond II	7.1	1410	2772	252	1932	1560
Pond III	8.4	1530	2554	360	1249	900
2-15						
Influent	10.5	1200	6742	602	4277	2883
Effluent	10.0	720	4017	370	2780	1825
Pond II	7.2	1160	3162	242	1805	1245
Pond III	8.5	1300	2685	452	960	1195

(a) all mg/l, except pH

Table A-19 IDAHO STATE HEALTH DEPARTMENT DATA (CONT'D.)

	pH	Total Alkalinity	Total Solids	Suspended Solids	COD	BOD
2-22-67						
Influent	9.6	1530	5620	720	4113	3223
Effluent	8.3	1040	3852	330	3562	2382
Pond II	7.6	1260	2868	258	2097	1485
Pond III	9.1	1440	2768	462	1292	1244
3-1						
Influent	10.8	1400	6224	680	4726	2400
Effluent	9.1	1120	3446	420	2932	1970
Pond II	7.5	1060	2686	300	2253	1323
Pond III	8.6	1380	2492	580	1616	815
3-8						
Influent	11.0	1460	5524	800	5864	3894
Effluent	9.6	1220	3528	620	3231	2262
Pond II	7.0	980	3040	480	2910	1907
Pond III	8.1	1300	2988	760	1606	1125
3-15						
Influent	10.8	1520	7227	920	8103	5584
Effluent	9.4	1100	4218	880	3843	2606
Pond II	7.4	940	3162	520	2327	1202
Pond III	8.2	1340	2626	640	1504	680
3-22						
Influent	11.2	1600	6887	840	7531	4500
Effluent	9.6	920	5184	800	4186	3000
Pond II	7.5	1020	3086	680	1760	1550
Pond III	8.0	1280	2768	540	1369	570
3-30						
Influent	11.1	1580	7224	1040	8472	6000
Effluent	9.8	1060	5586	880	6384	4400
Pond II	7.6	980	3018	660	2818	1800
Pond III	7.8	1220	2664	580	1142	650

Table A-19 IDAHO STATE HEALTH

DEPARTMENT DATA (CONT'D.)

	pH	Total Alkalinity	Total Solids	Suspended Solids	COD	BOD
4-4-67						
Influent	10.8	1540	8122	860	6848	3450
Effluent	9.7	1110	5484	820	4740	2850
Pond II	7.4	860	2928	680	2404	1325
Pond III	8.0	1320	2410	620	780	480
4-19						
Influent	12.2	1610	7068	920	6744	4500
Effluent	10.4	1200	5226	780	3270	1960
Pond II	7.2	920	2779	620	2246	1800
Pond III	8.0	1220	2208	600	756	450
4-26						
Influent	11.8	1720	7226	1080	6286	4200
Effluent	10.2	1460	4867	600	3178	1950
Pond II	7.4	880	2818	580	2184	1300
Pond III	8.0	1180	2016	460	724	390/270
5-3						
Influent	11.4	1880	7868	1240	5204	3286
Effluent	10.0	1520	5812	940	3393	2018
Pond II	7.2	960	3024	880	2089	1354
Pond III	8.2	1240	2287	540	1496	800
5-9						
Influent	11.2	1780	8277	1620	9856	5439
Effluent	10.2	1600	6103	1240	3763	3450
Pond II	7.4	1120	2928	1080	2284	1486
Pond III	8.0	1440	2614	960	1990	912
5-16						
Influent	11.5	1050	6116	1728	8725	4800
Effluent	10.6	870	3428	1408	4054	2227
Pond II	7.2	925	2868	1204	2394	1438
Pond III	8.4	1370	2820	1048	2051	1126

Table A-19 IDAHO STATE HEALTH DEPARTMENT DATA (CONT'D.)

	pH	Total Alkalinity	Total Solids	Suspended Solids	COD	BOD
5-23-67						
Influent	11.8	1840	6052		4691	3000
Effluent	11.1	960	4526		2352	2360
Pond I	7.6	1360	3420		1175	732
Pond II	7.2	1020	2842		2055	1245
Pond III	8.0	1400	2382		1796	553

APPENDIX C

Analytical Procedures

ANALYTICAL PROCEDURES

All of the analyses performed on the collected samples were in accordance with the 12th edition of Standard Methods with the exception of the volatile acids determination and the short-term modified Canner's Association chemical oxygen demand, COD_m, tests. The methods used for these parameters are outlined below.

The volatile acids determinations were made following the procedure outlined in "Volatile Acids by Direct Titration," by DiLallo and Albertson.(5) The sample is first titrated with H_2SO_4 to a pH of 3.5 to 3.3. Then, it is boiled lightly for at least 3 minutes, and cooled to its original temperature. It is then adjusted to pH 4.0 with 0.05 N sodium hydroxide. The sample is then titrated with the 0.05 N sodium hydroxide from pH 4.0 to 7.0. The volatile acid alkalinity is then calculated from:

$$\text{Volatile acid alkalinity} = \frac{\text{ml } 0.05\text{N NaOH} \times 2{,}500}{\text{ml. sample}}$$

The volatile acids are then calculated as 1.5 x volatile acids alkalinity for volatile acid alkalinities greater than 180 mg/l and 1.0 x volatile acid alkalinity for volatile acid alkalinities less than 180 mg/l.

This test was concise and convenient and appeared to give accurate results.

The National Canner's Association modified chemical oxygen demand determination was performed in accordance with procedures outlined in "Chemical Oxygen Demand as a Test of Strength of Cannery Waste Water," by Rose and Mercer, National Canner's Association Research Laboratories, Berkeley, California, May 16, 1956. However, a 20 minute digestion period was substituted for the recommended 10 minutes. The method consists of boiling the sample in a mixture of sulfuric and phosphoric acids for 20 minutes, cooling to room temperature, diluting with distilled water and titration with 0.1N Sodium Thiosulfate solution with the addition of KI crystals and 2 ml of starch solution. The endpoint occurs when the sample first turns light blue-green.

The COD_m test gave fairly consistent correlation with the standard method COD_s test for the clarifier effluent, but diverged from it for the pond effluents. The test is extremely sensitive to digestion time and temperature variations and to laboratory techniques due to the incomplete oxidation which occurs during its digestion period. Replicate samples did not reproduce accurately. The ratios of BOD to both COD_s and COD_m are shown in Table A-20. The BOD/COD_s ratios show a consistently higher correlation than the BOD/COD_m ratios.

The COD_m results were not an adequate indications of the efficiency of secondary waste effluent.

TABLE A-20 COMPARISONS BETWEEN BOD:COD_s RATIO and BOD:COD_m RATIO

	BOD/COD_s [a]	BOD/COD_m [b]
Clarifier Influent	0.46 ± 0.10 [c]	0.63 ± 0.22
Clarifier Effluent	0.50 ± 0.07	0.74 ± 0.20
Pond II Effluent	0.51 ± 0.06	1.80 ± 0.38
Pond III Effluent	0.23 ± 0.12	0.47 ± 0.31

(a) 24 sets of values

(b) 13 sets of values

(c) Mean $\pm$ 1 standard deviation

APPENDIX D

Figures

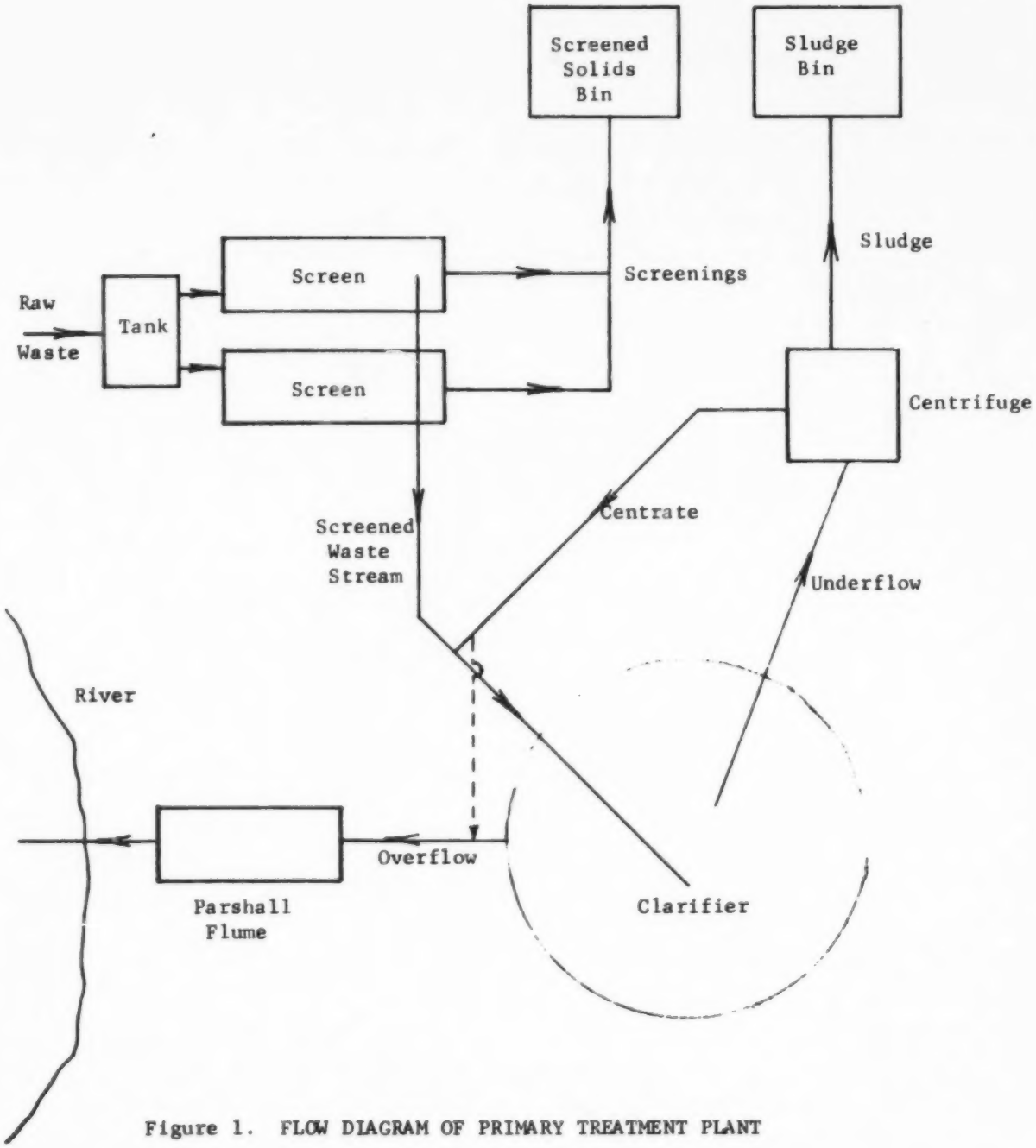

Figure 1. FLOW DIAGRAM OF PRIMARY TREATMENT PLANT

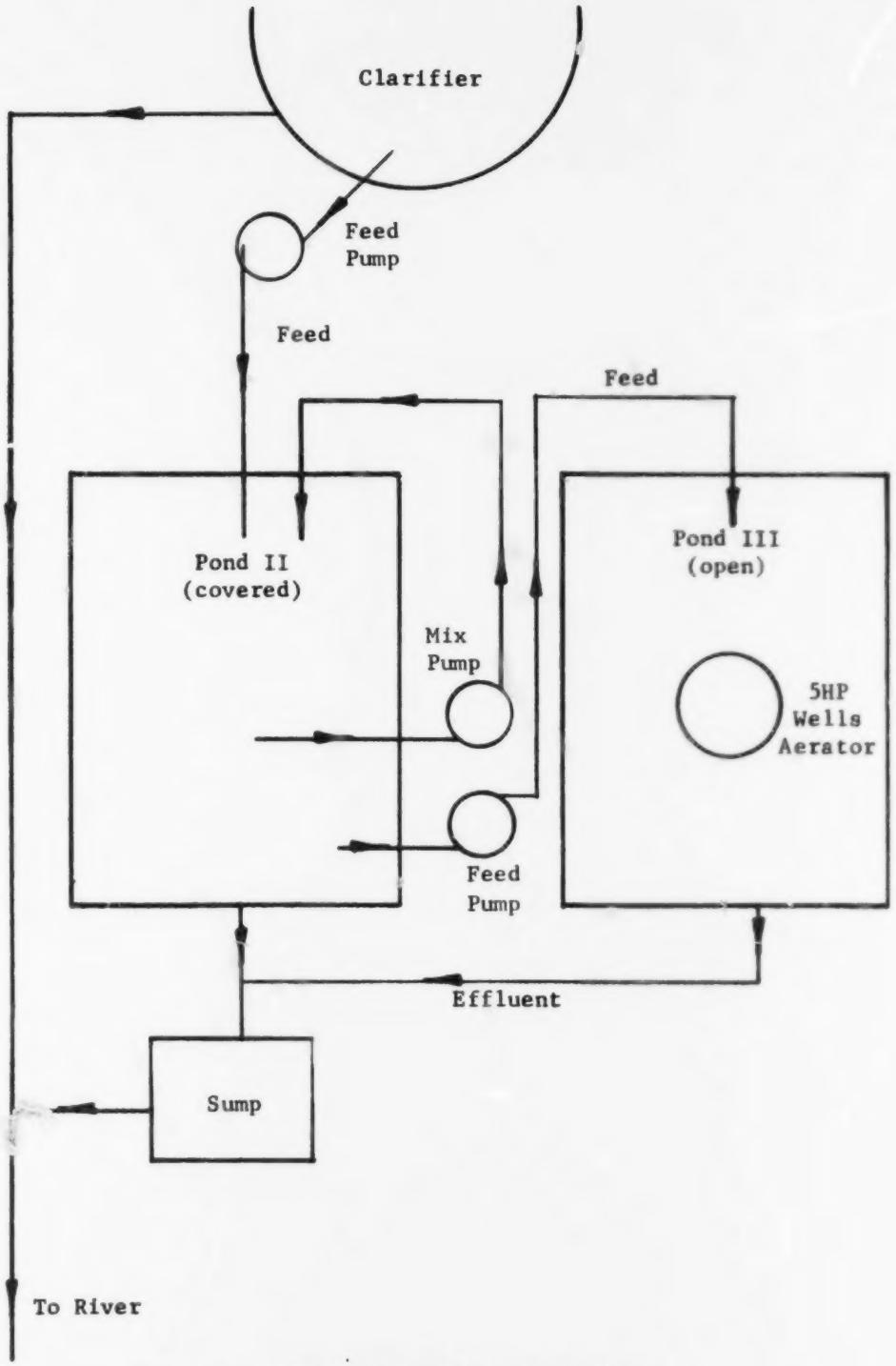

Figure 2. FLOW DIAGRAM OF PILOT PLANTS

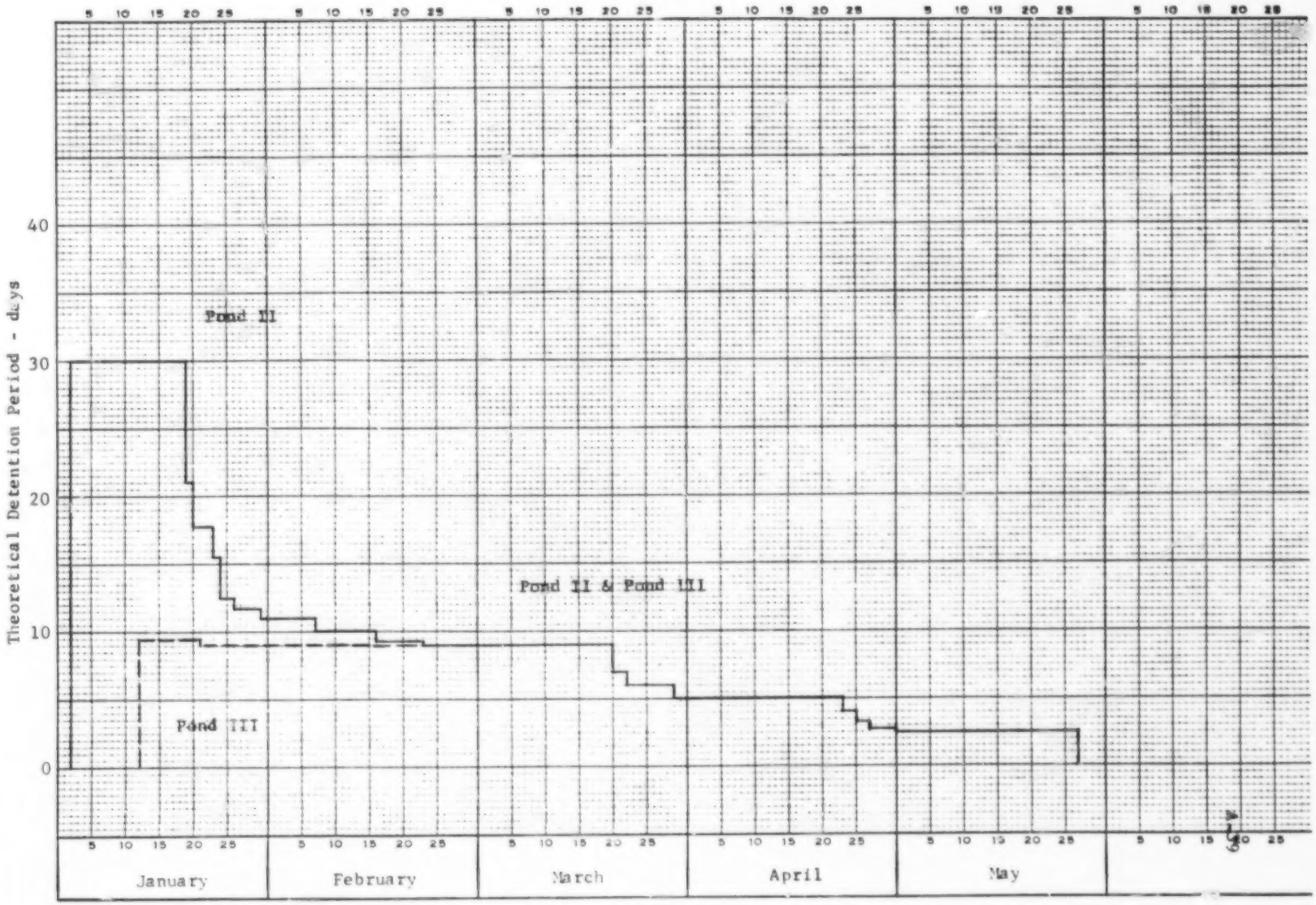

Figure 3. HYDRAULIC LOADING PATTERN - 1967

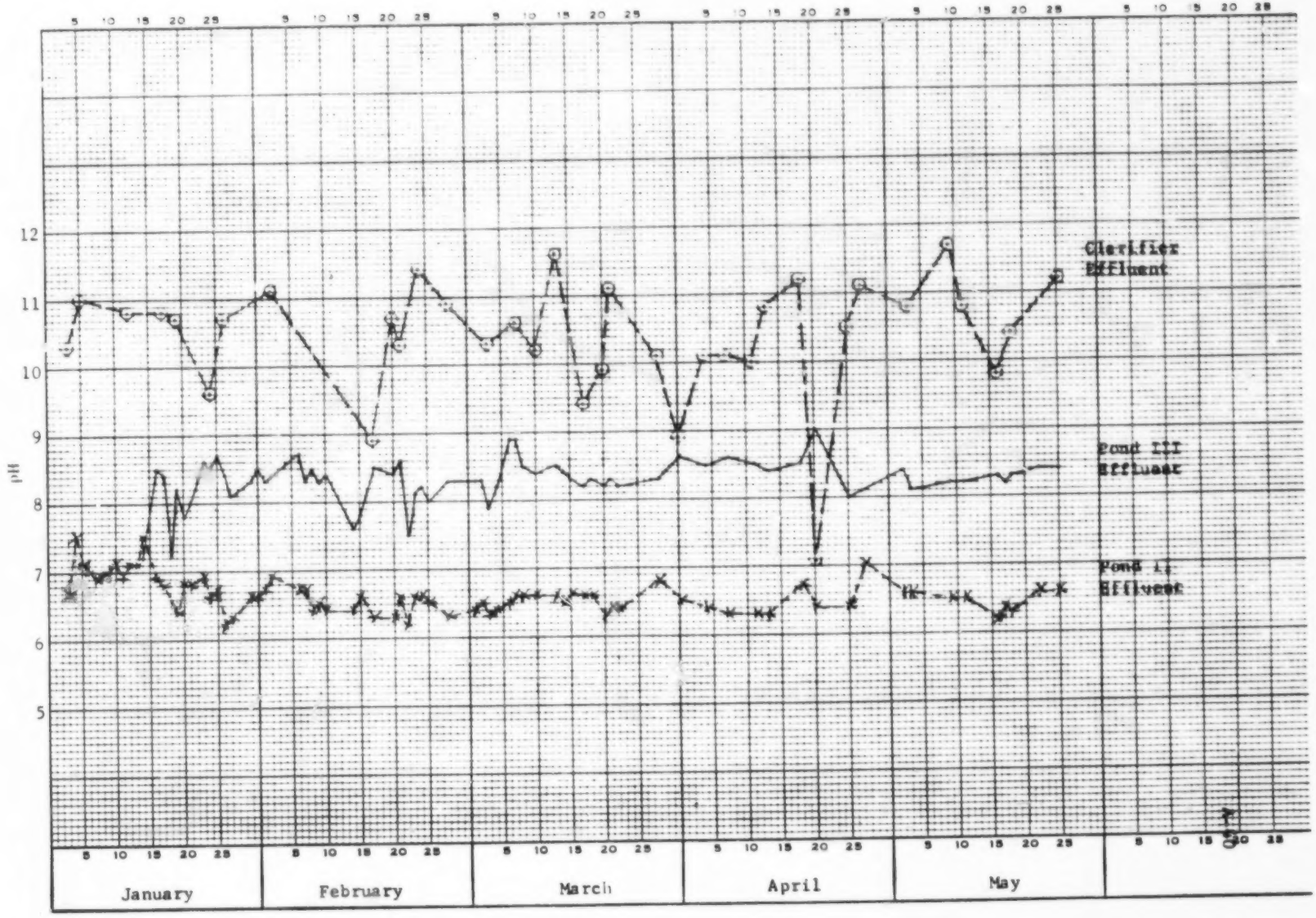

Figure 4. VARIATION IN pH

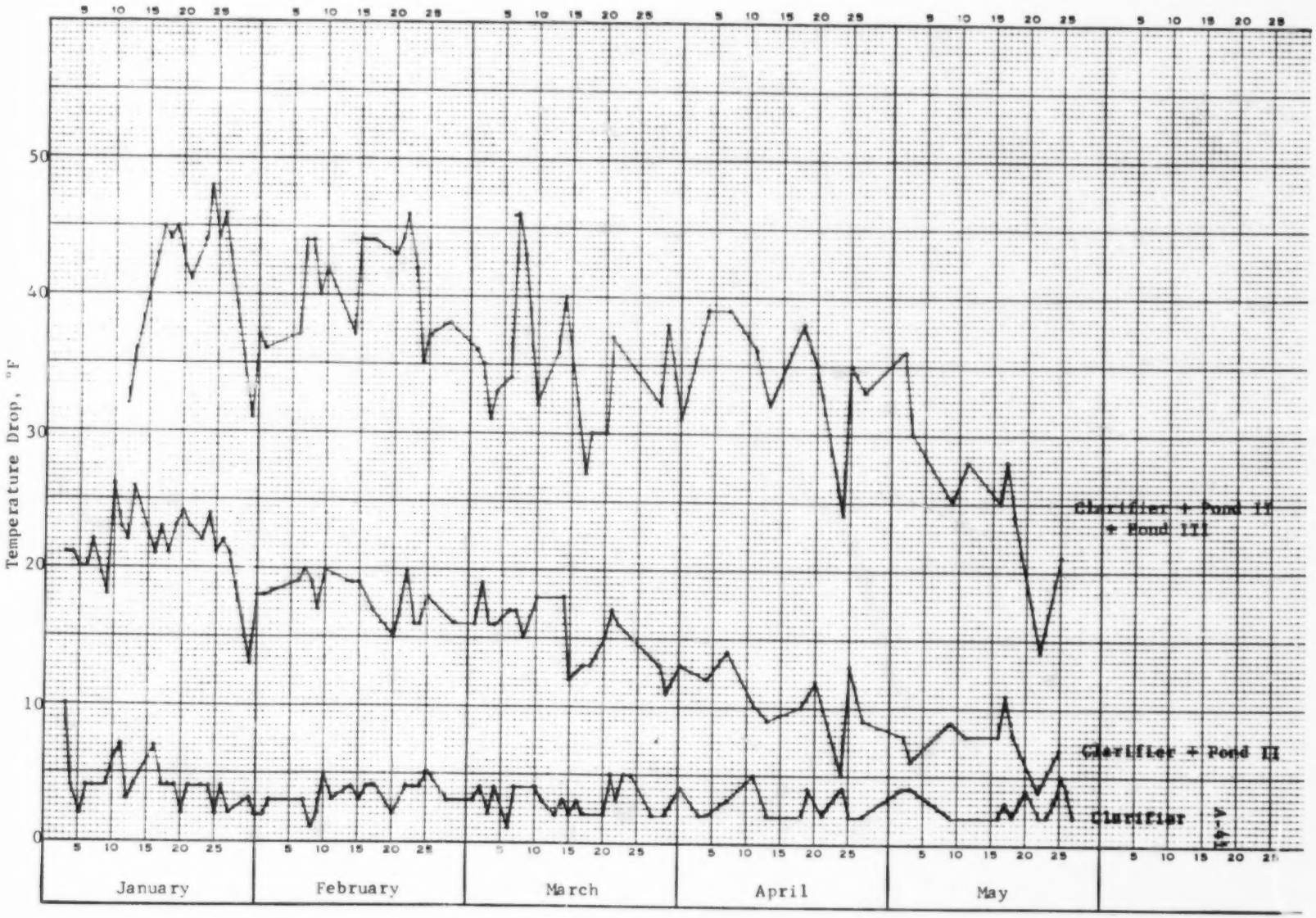

Figure 5. TEMPERATURE CHANGES OF WASTE STREAM

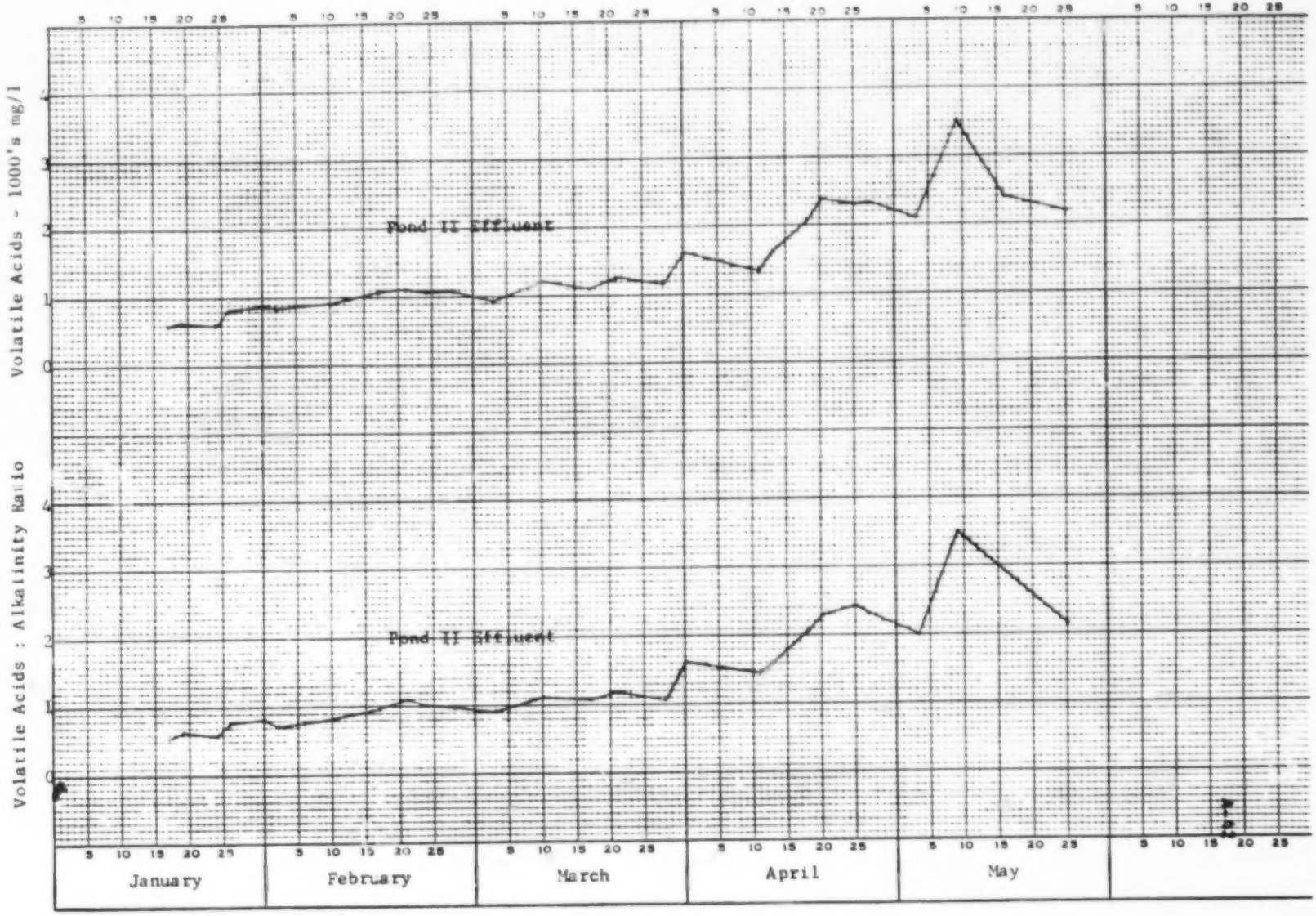

Figure 6. ALKALINITY AND VOLATILE ACIDS RELATIONSHIPS

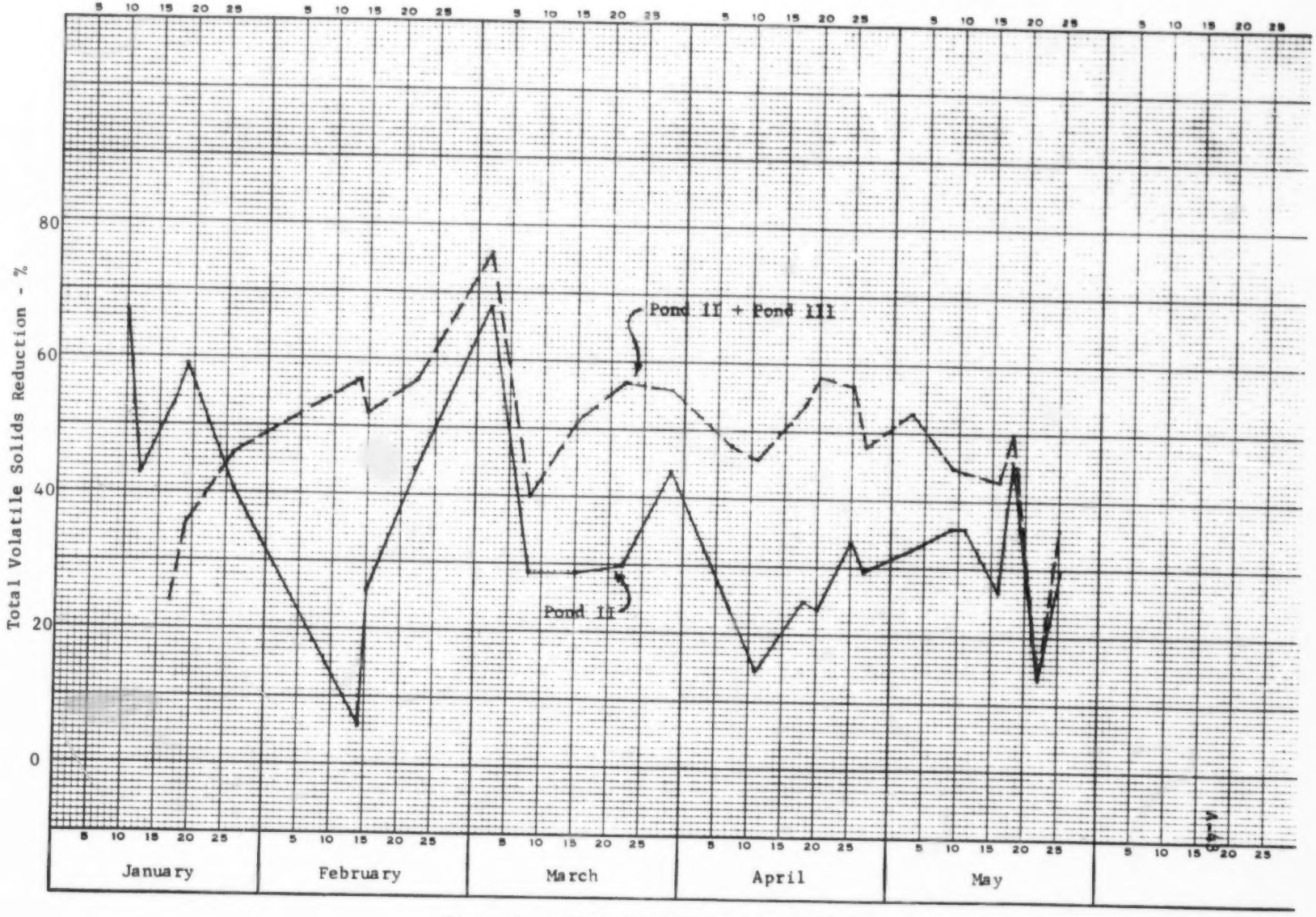

Figure 7. TOTAL VOLATILE SOLIDS REDUCTION

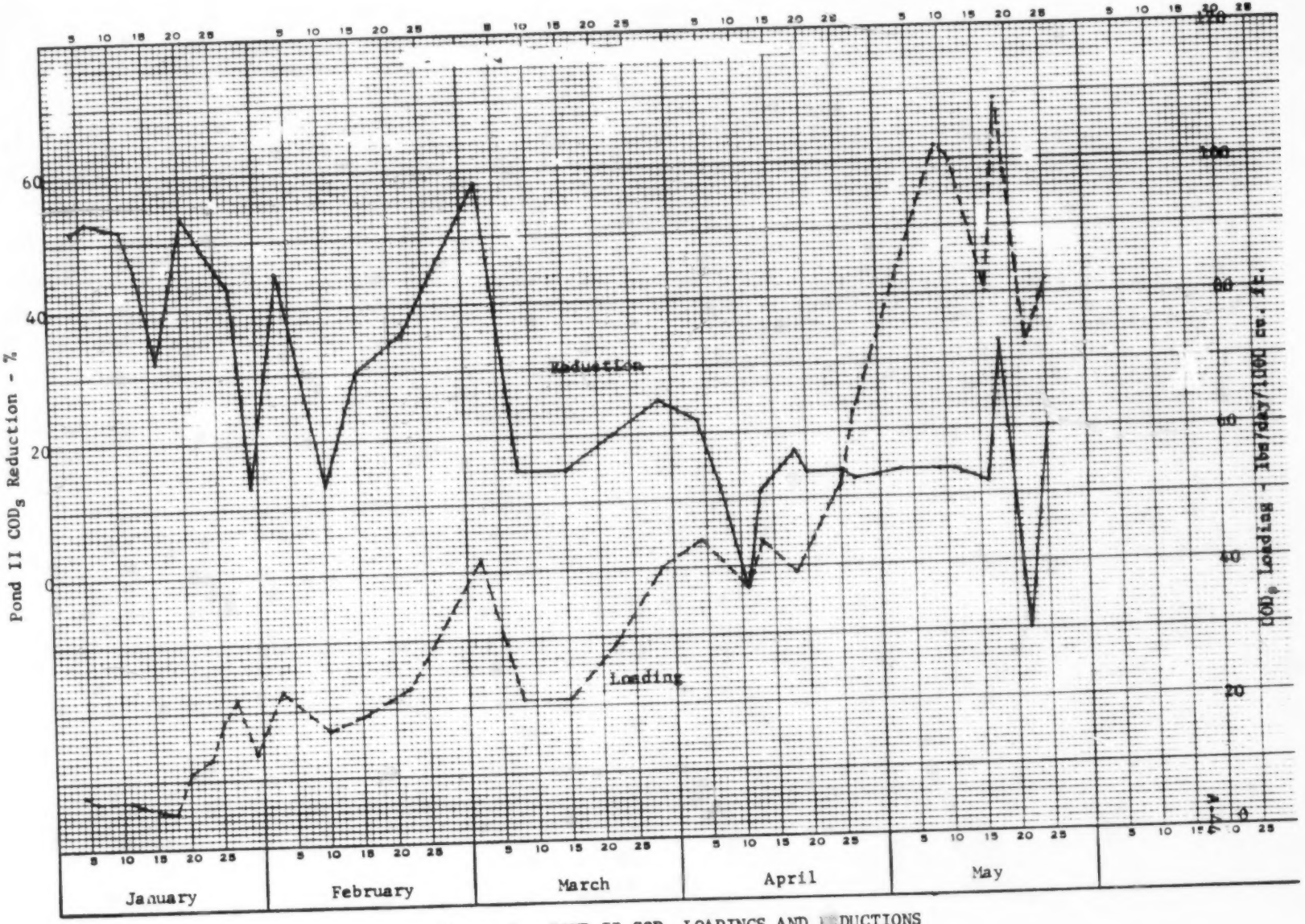

Figure 8. POND II COD_s LOADINGS AND REDUCTIONS

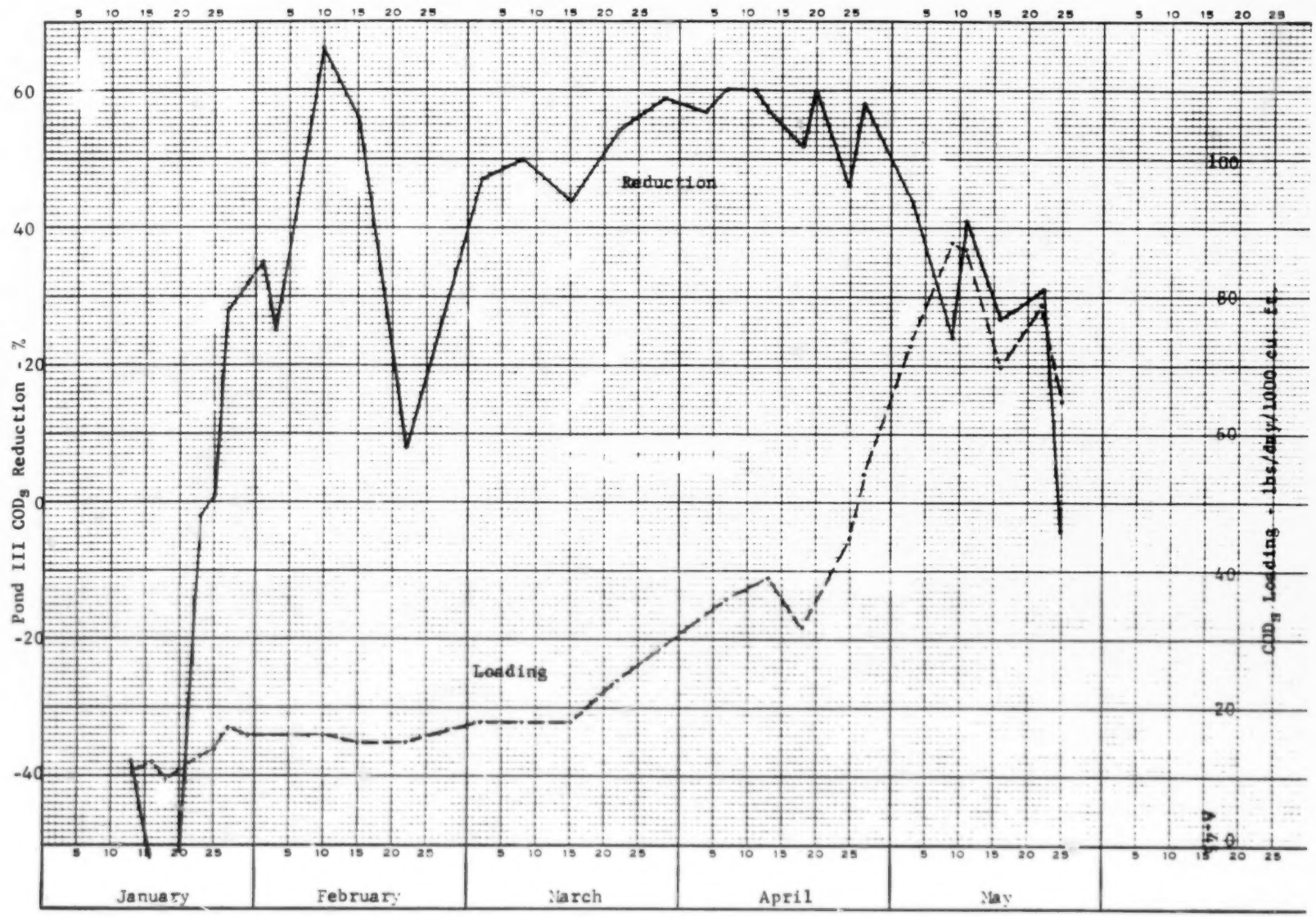

Figure 9. POND III COD_s LOADINGS AND REDUCTIONS

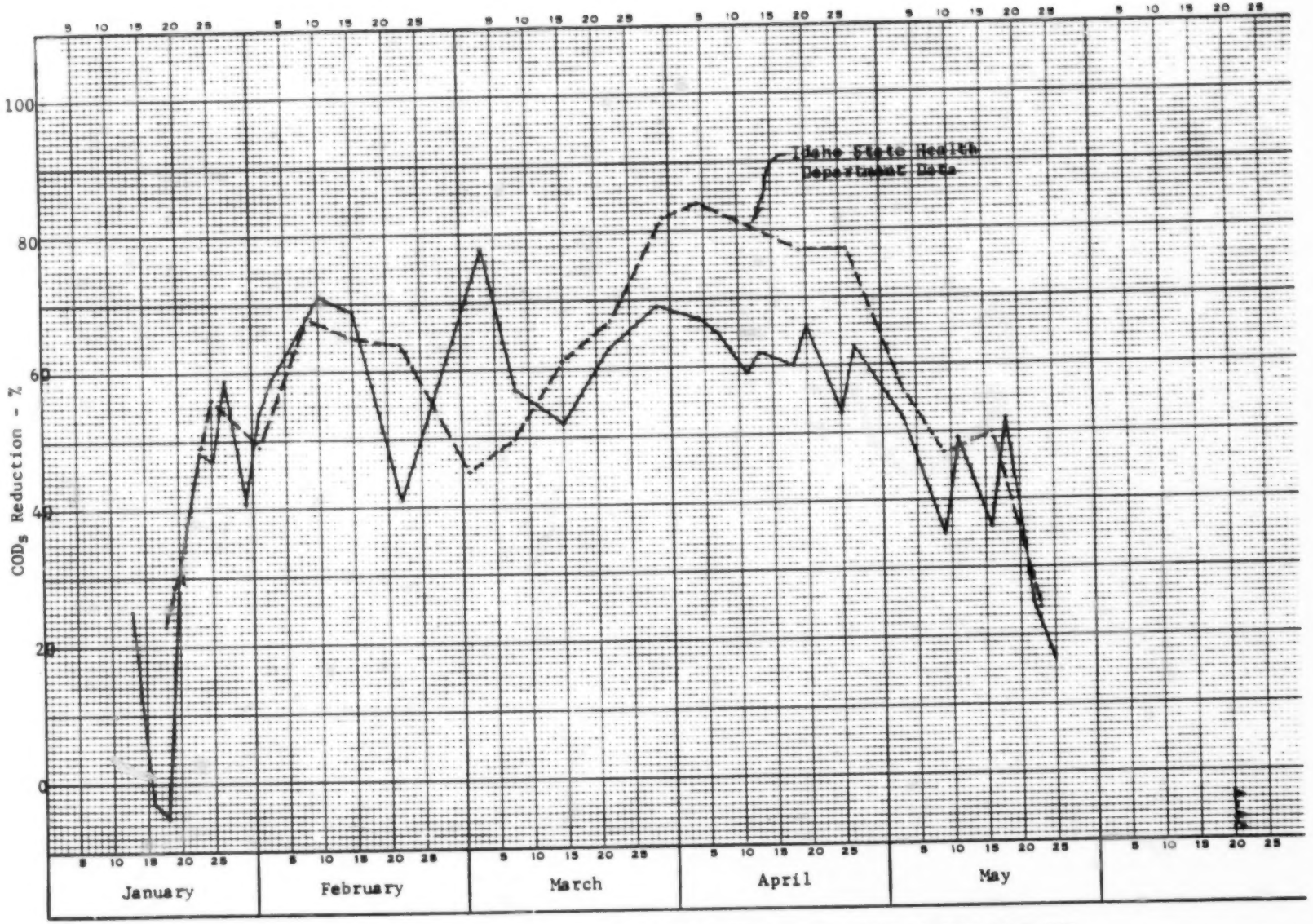

Figure 10. DATA COMPARISON ON COD_s REDUCTIONS ACROSS POND II PLUS POND III

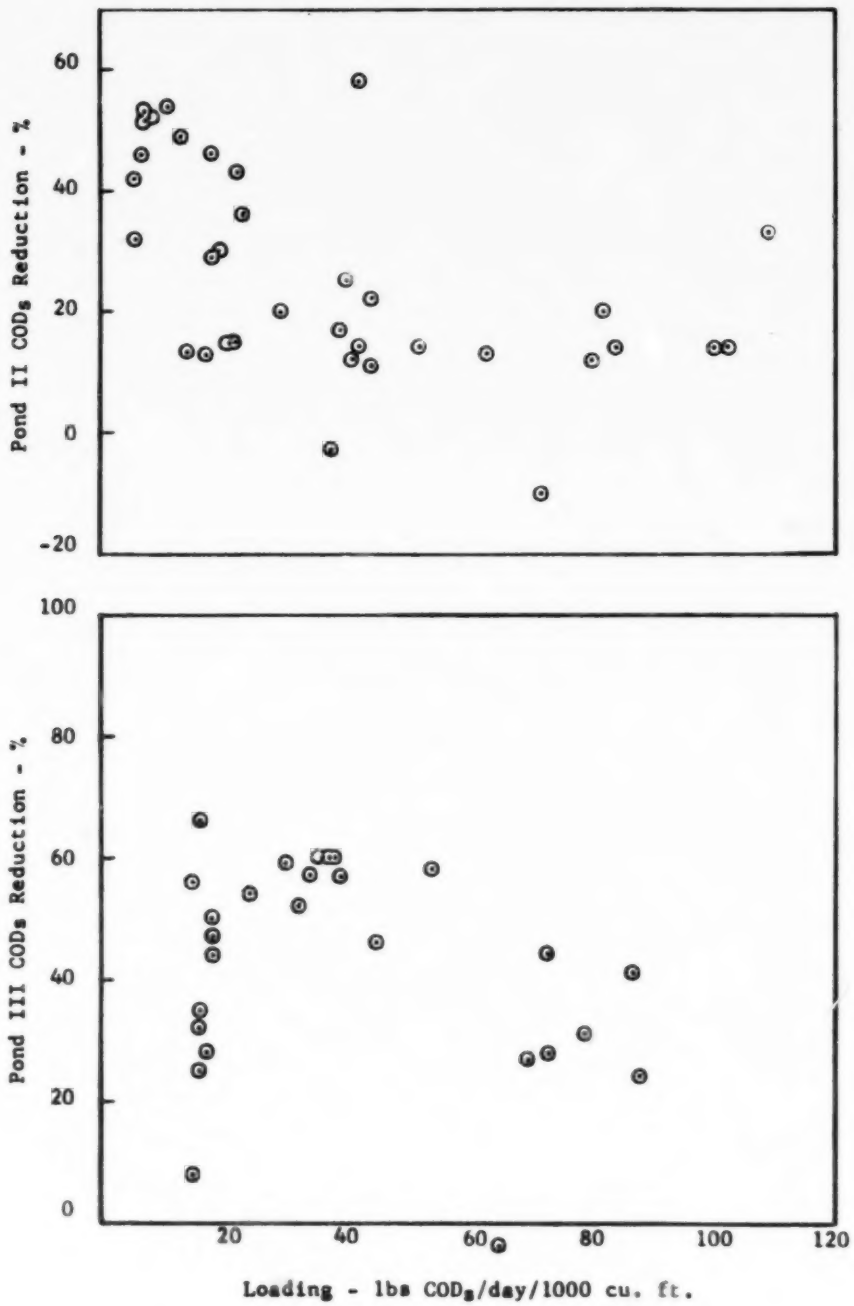

Figure 11. INFLUENCE OF POND LOADINGS ON COD_S REDUCTION

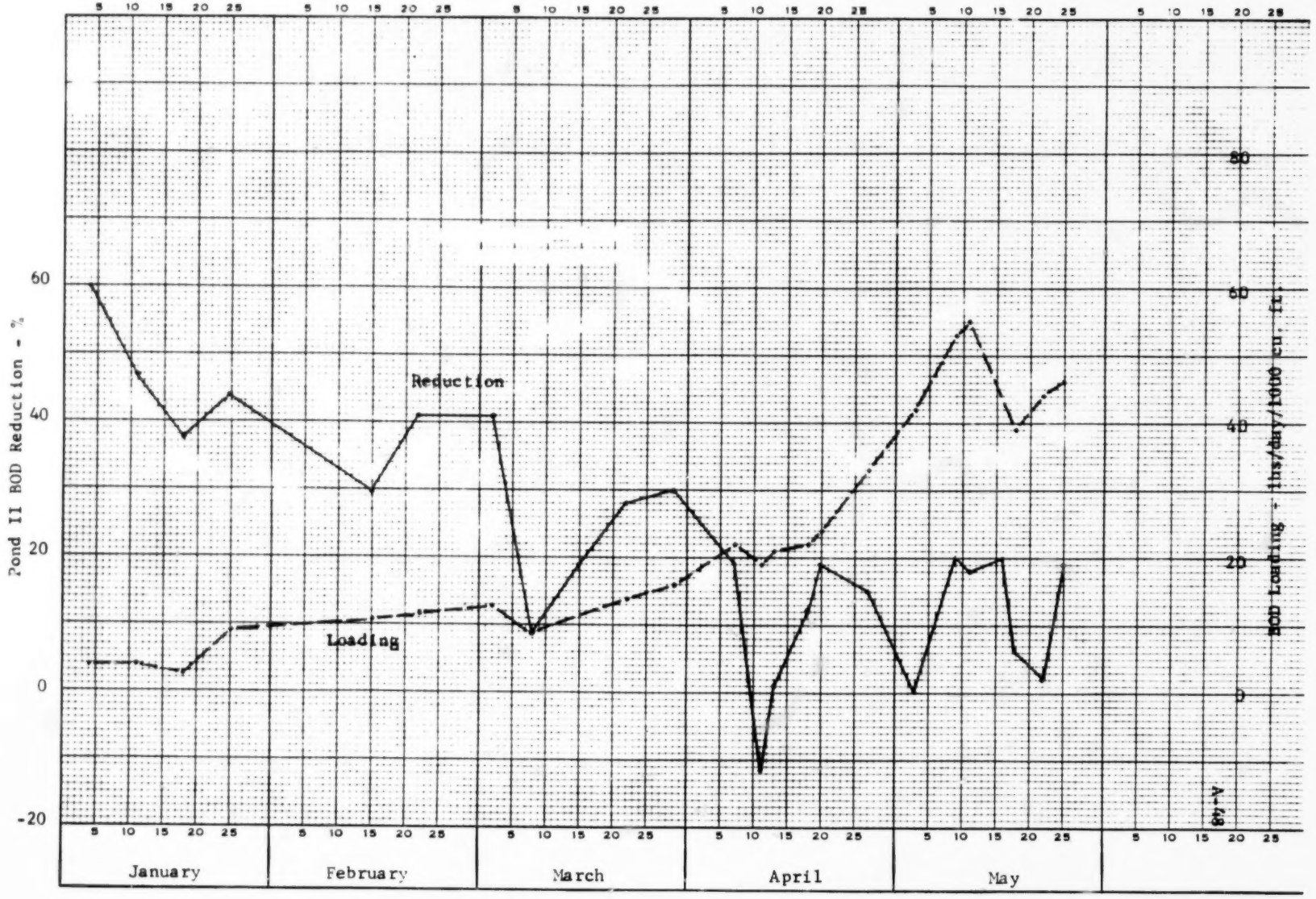

Figure 12. BOD LOADINGS ON AND REDUCTIONS BY ANAEROBIC POND II

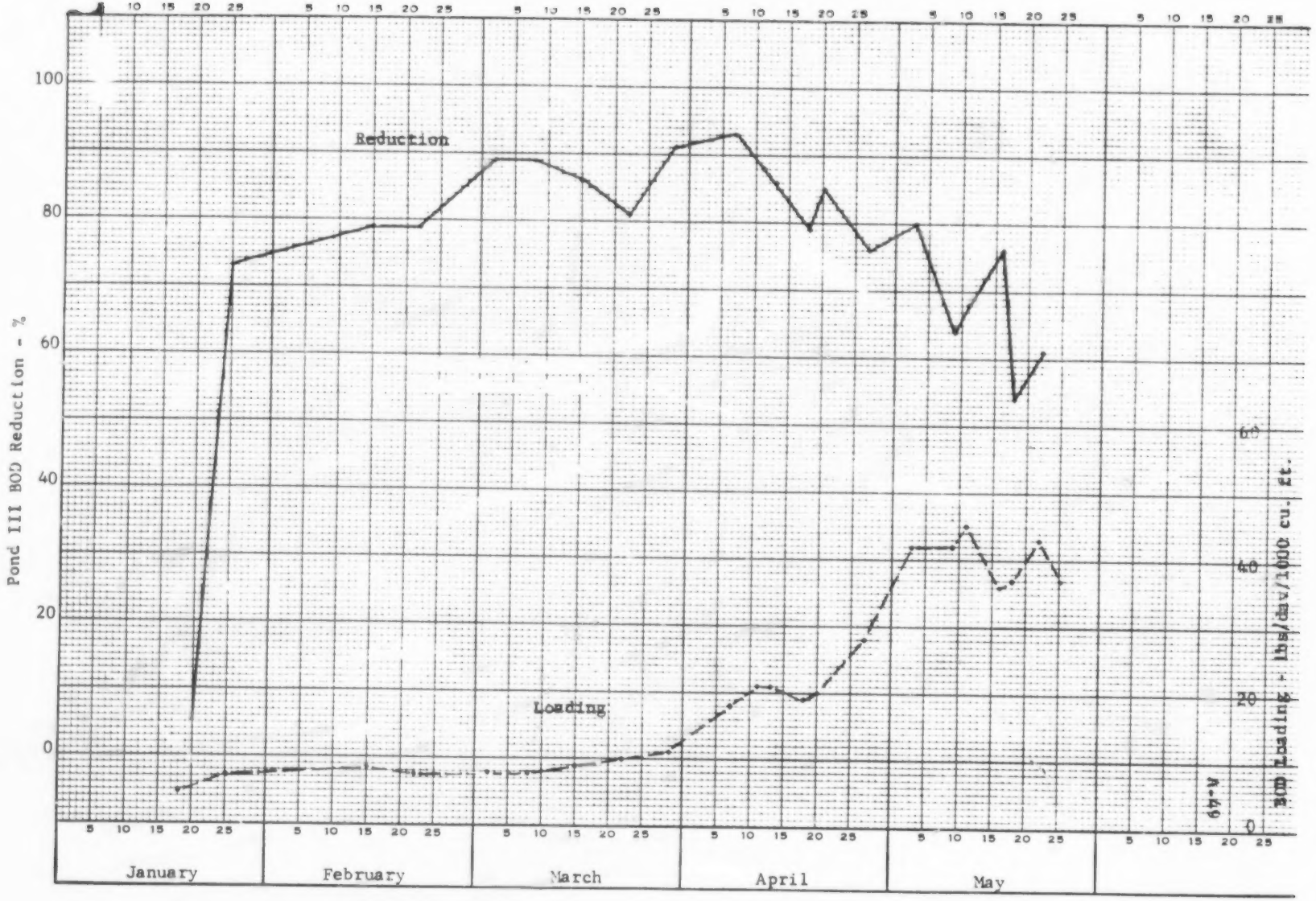

Figure 13. BOD LOADINGS ON AND REDUCTIONS BY AEROBIC POND III

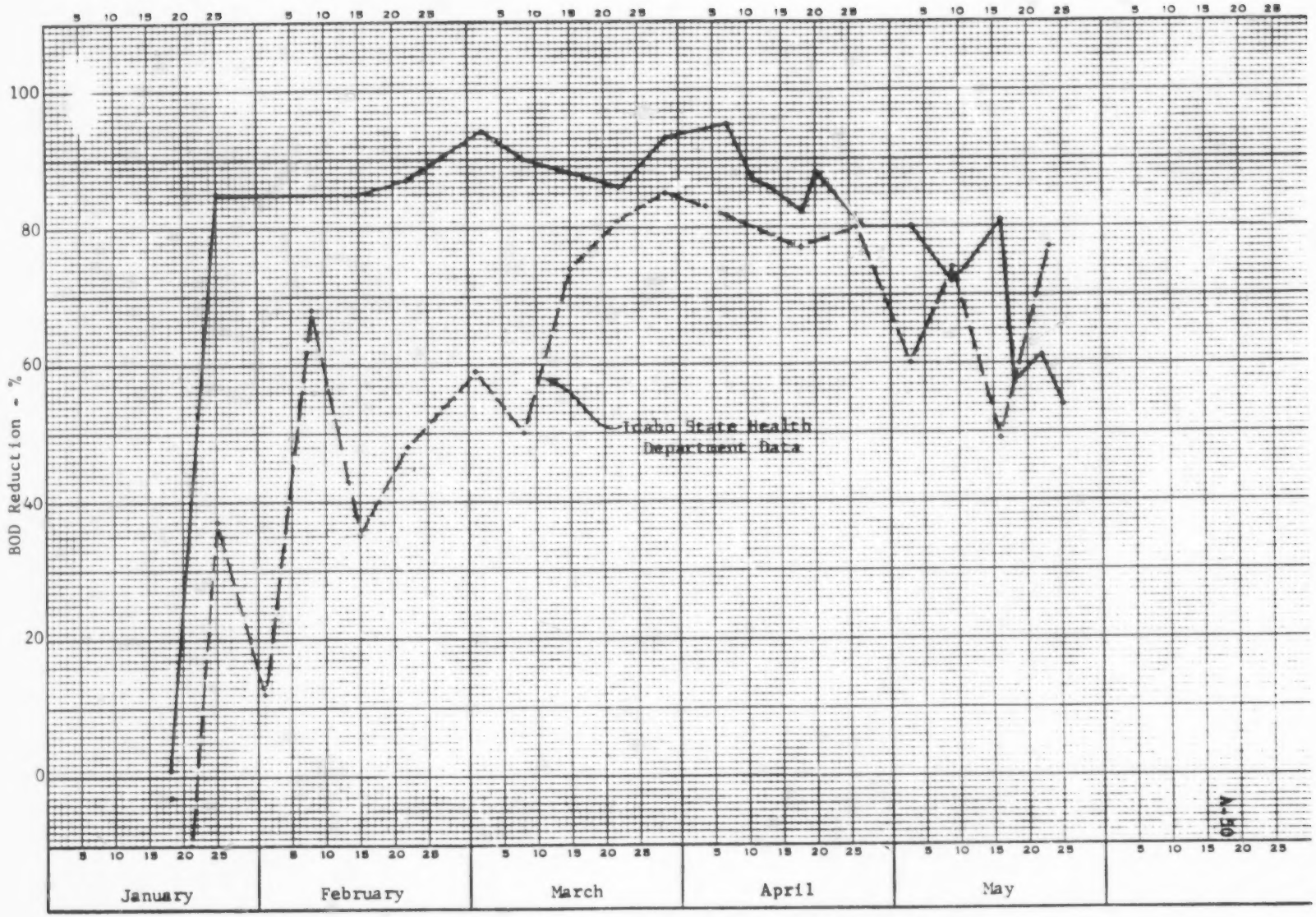

Figure 14. TOTAL BOD REDUCTION ACROSS POND II PLUS POND III

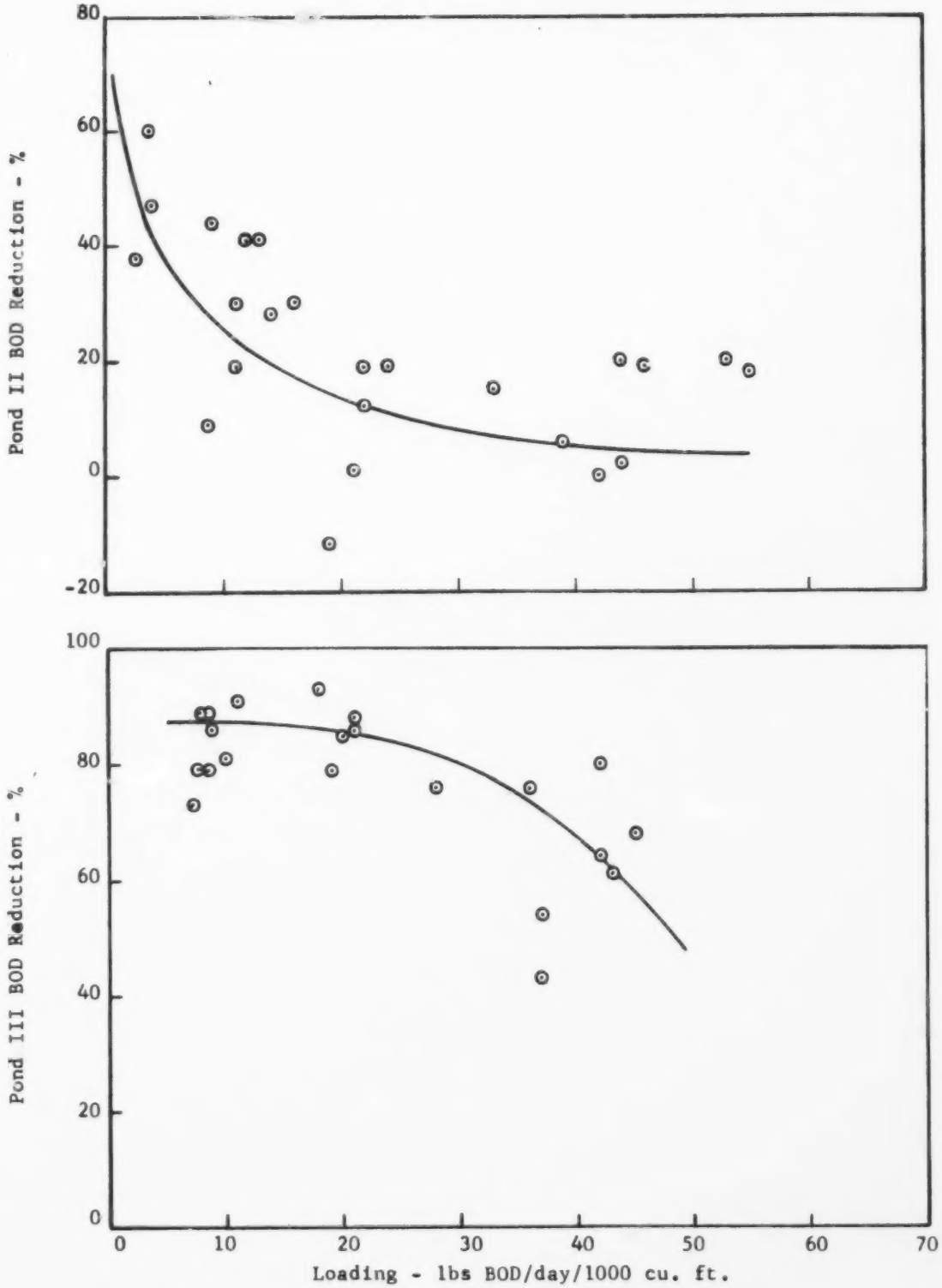

Figure 15. INFLUENCE OF POND LOADING ON BOD REDUCTION

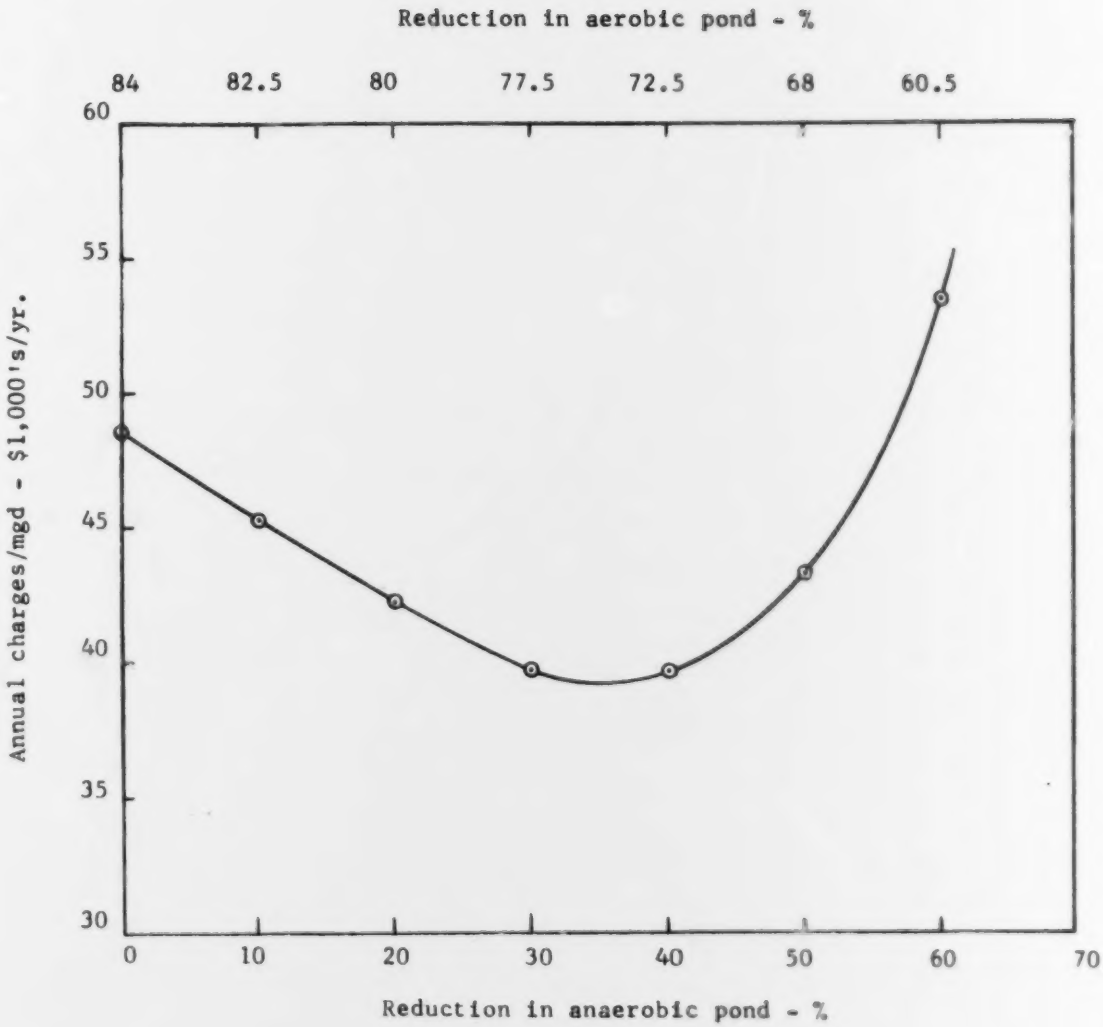

Figure 16. PRELIMINARY ESTIMATE OF ANNUAL CHARGES